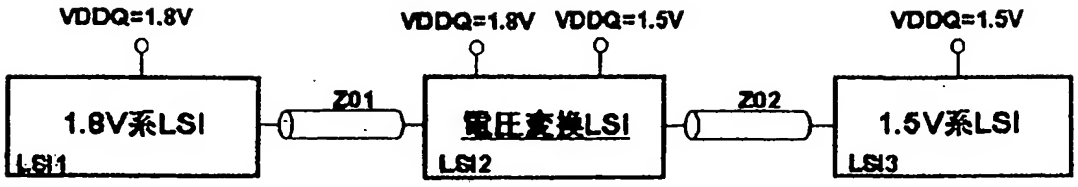


FIG. 1 (PRIOR ART)

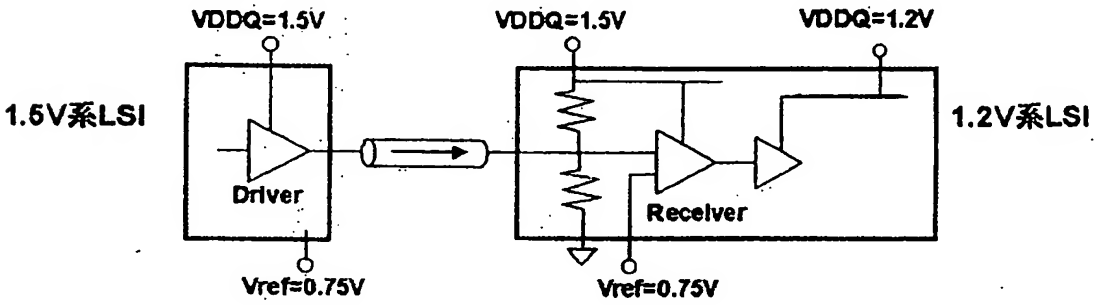


FIG. 2 (PRIOR ART)

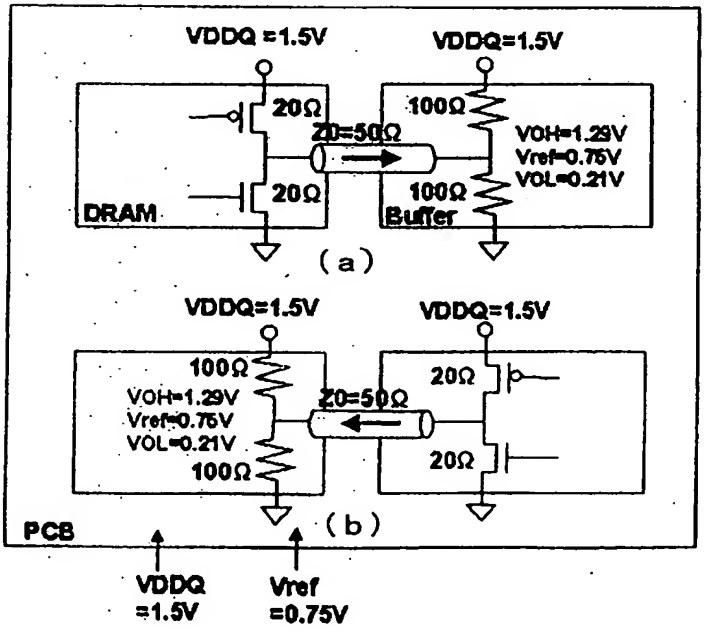


FIG. 3 (PRIOR ART)

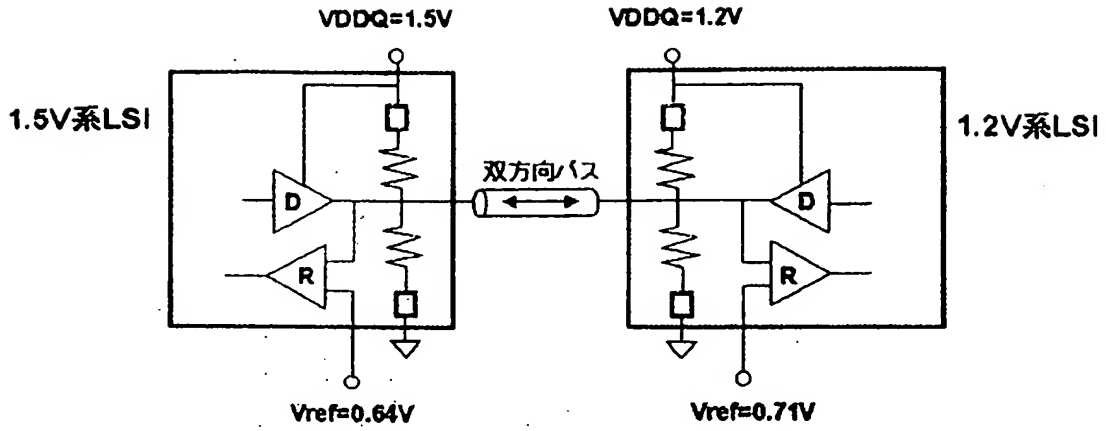


FIG. 4 (PRIOR ART)

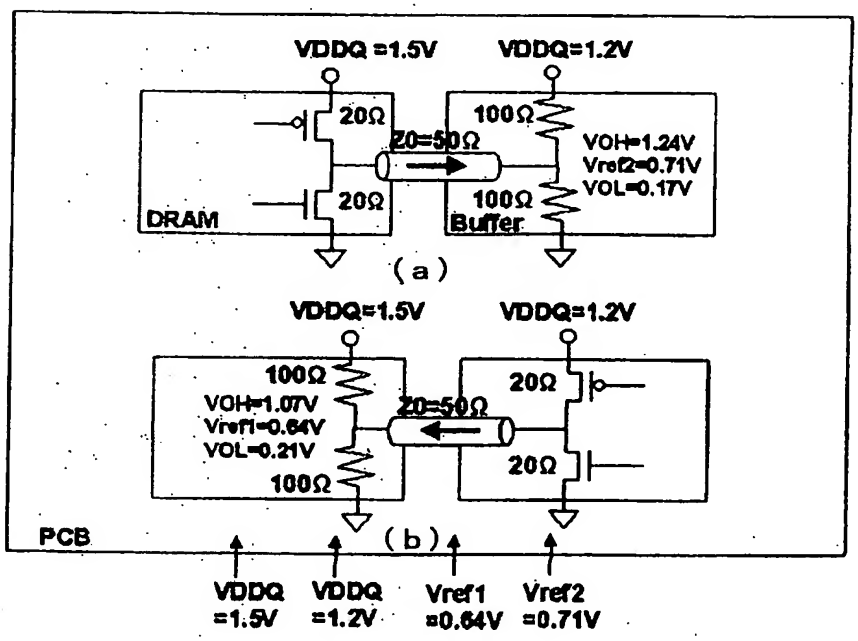


FIG. 5 (PRIOR ART)

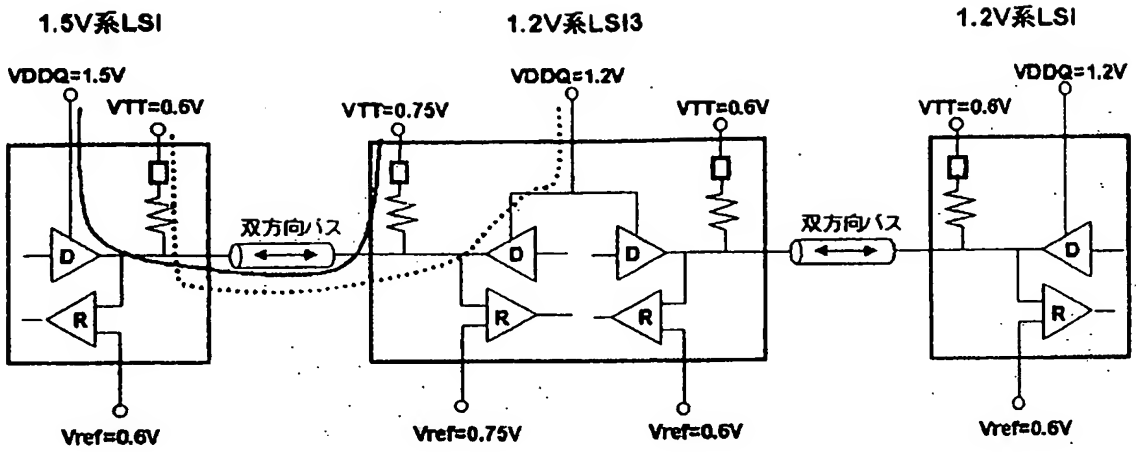


FIG. 6 (PRIOR ART)

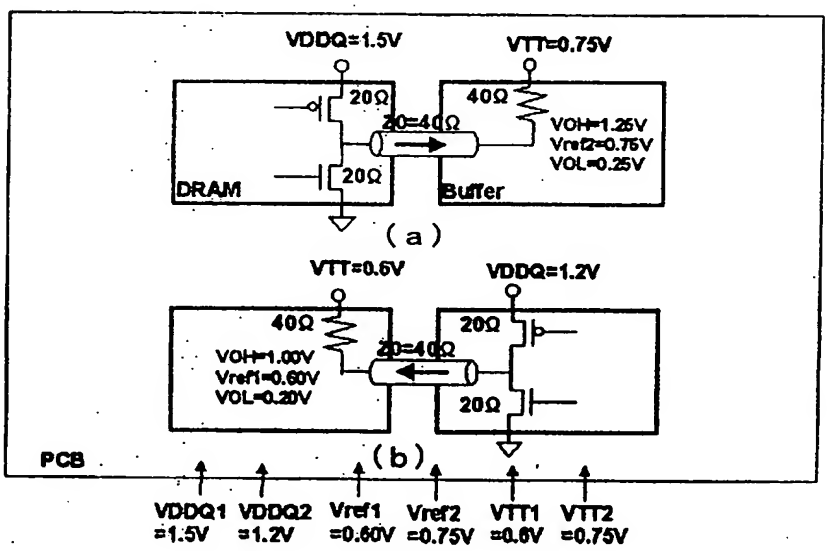


FIG. 7 (PRIOR ART)

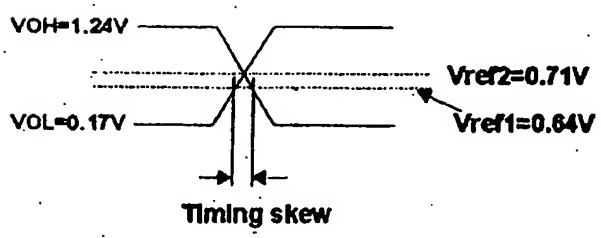


FIG. 8 (PRIOR ART)

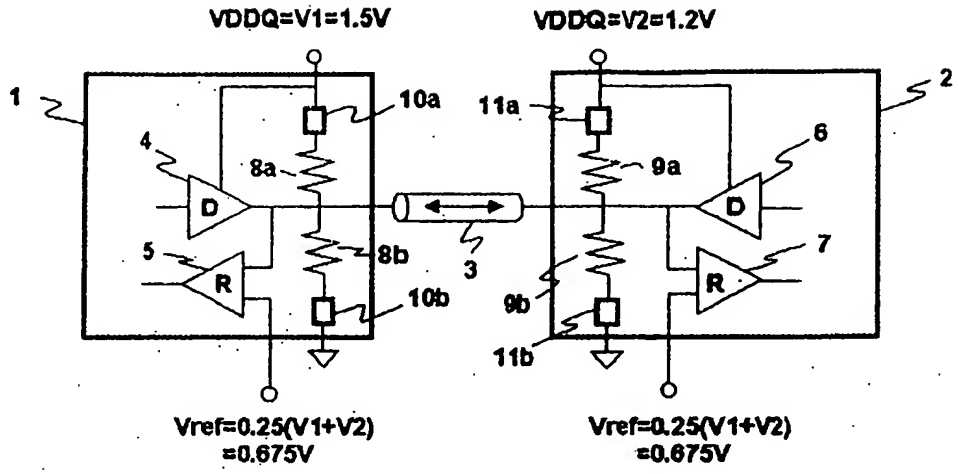

VDDQ=V1=1.5V
VDDQ=V2=1.2V
1
2
10a
11a
4
8a
9a
6
D
D
5
R
8b
3
7
R
9b
10b
11b
Vref=0.25(V1+V2)
=0.675V
Vref=0.25(V1+V2)
=0.675V

FIG. 9

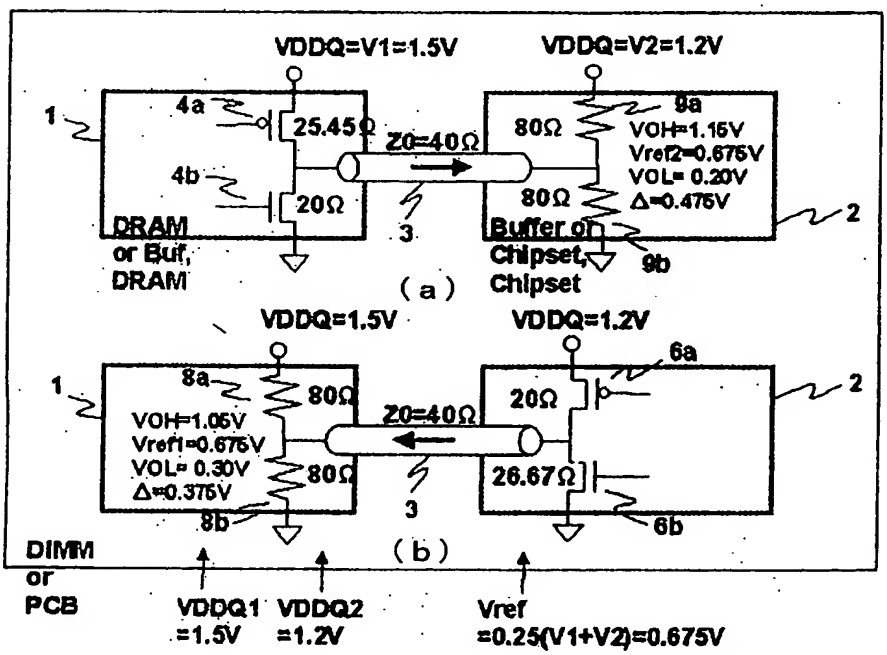

VDDQ=V1=1.5V
VDDQ=V2=1.2V
1
4a
25.45Ω
Z0=40Ω
80Ω
9a
VOH=1.15V
Vref2=0.675V
VOL= 0.20V
Δ=0.475V
4b
20Ω
80Ω
2
3
DRAM
or Buf,
DRAM
Buffer or
Chipset,
Chipset
9b
(a)
VDDQ=1.5V
VDDQ=1.2V
6a
1
8a
80Ω
20Ω
2
VOH=1.05V
Vref1=0.675V
VOL= 0.30V
Δ=0.375V
Z0=40Ω
80Ω
26.67Ω
3
8b
6b
(b)
DIMM
or
PCB
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=0.25(V1+V2)=0.675V

FIG. 10

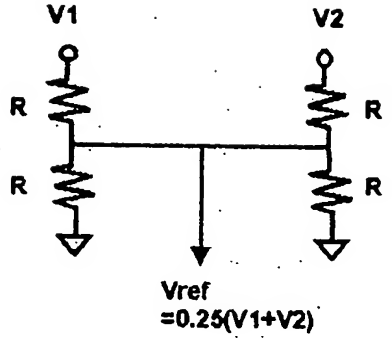


FIG. 11A

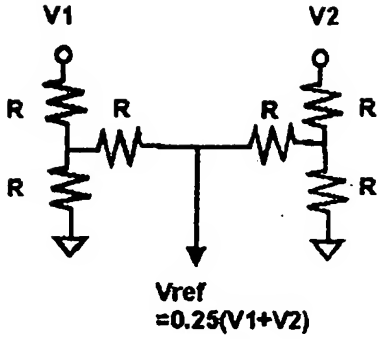


FIG. 11B

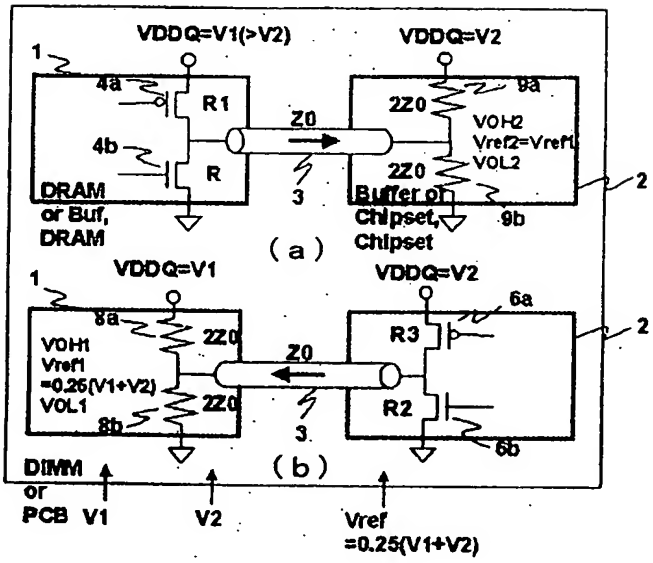


FIG. 12

$R \leq Z0$

$R1=Z0(V2 \cdot Z0-V1 \cdot R-V1 \cdot Z0)/(V2 \cdot R-V1 \cdot Z0-V1 \cdot R)$

$VOH2=(V1-0.5V2)Z0/(R1+Z0)+0.5V2$
$VOL2=0.5V2 \cdot R/(Z0+R)$

$R3 \leq Z0$

$R2=Z0(V1 \cdot Z0+V2 \cdot R3-V2 \cdot Z0)/(V1 \cdot R3+V2 \cdot Z0-V2 \cdot R3)$

$VOH1=(V2-0.5V1)Z0/(R3+Z0)+0.5V1$
$VOL1=0.5V1 \cdot R2/(R2+Z0)$

$Vref=Vref2=0.25(V1+V2)$

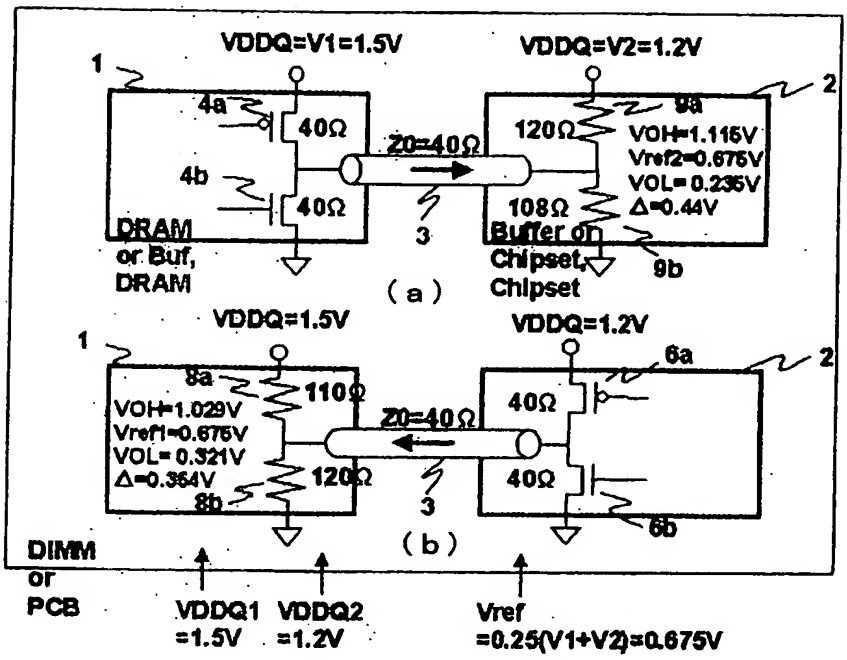
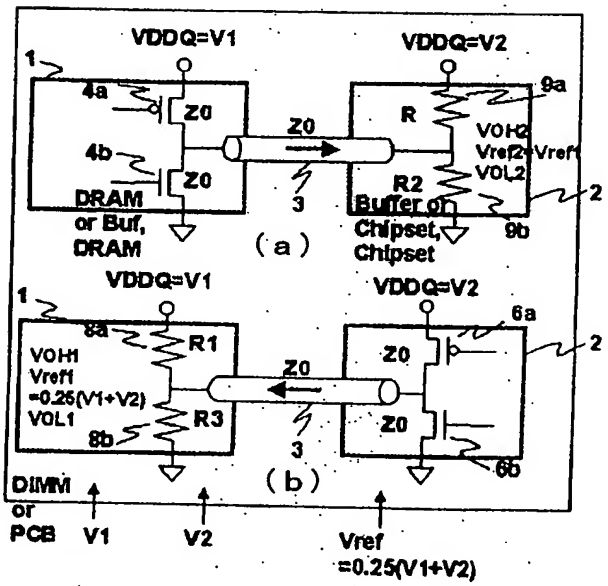


FIG. 13



$R \geq 2Z0$

$R2=R \cdot Z0(V1+V2) / (V1 \cdot R+3V2 \cdot Z0-V1 \cdot Z0-V2 \cdot R)$

$VOH2=(R \cdot R2 \cdot V1+R2 \cdot Z0 \cdot V2) / (Z0 \cdot R+R2 \cdot R+R2 \cdot Z0)$

$VOL2=R2 \cdot Z0 \cdot V2/(Z0 \cdot R2+R \cdot R2+R \cdot Z0)$

$R3 \geq 2Z0$

$R1=R3 \cdot Z0(3V1-V2) / (V1 \cdot R3+V1 \cdot Z0-V2 \cdot R3+V2 \cdot Z0)$

$VOH1=(R3 \cdot R1 \cdot V2+R3 \cdot Z0 \cdot V1) / (Z0 \cdot R1+R1 \cdot R3+R3 \cdot Z0)$

$VOL1=R3 \cdot Z0 \cdot V1/(Z0 \cdot R1+R3 \cdot R1+R3 \cdot Z0)$

$Vref=Vref2=0.25(V1+V2)$

FIG. 14

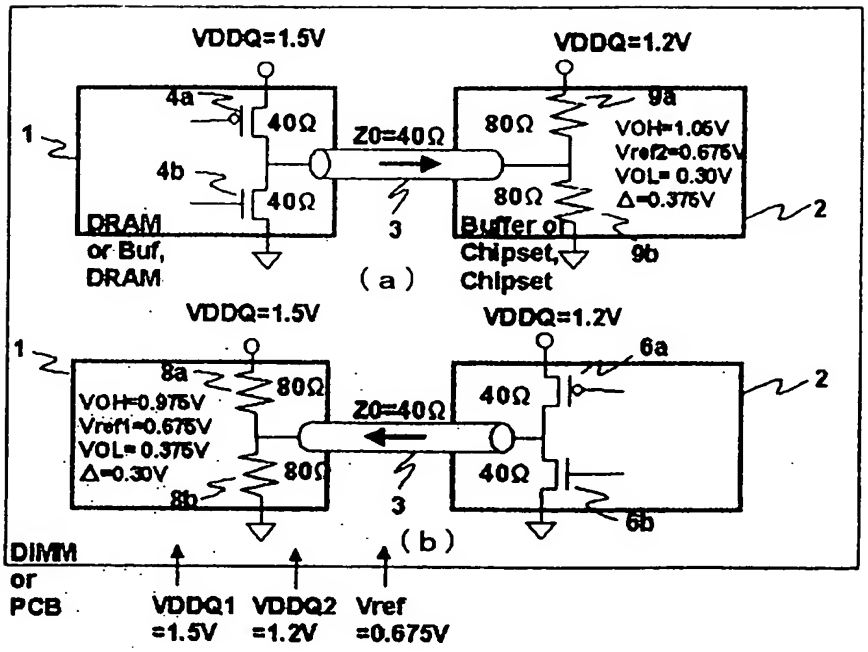

VDDQ=1.5V
VDDQ=1.2V
4a
40Ω
Z0=40Ω
80Ω
9a
VOH=1.05V
Vref2=0.675V
VOL= 0.30V
Δ=0.375V
1
4b
40Ω
80Ω
2
DRAM
or Buf,
DRAM
3
Buffer of
Chipset,
Chipset
9b
(a)
VDDQ=1.5V
VDDQ=1.2V
1
8a
80Ω
6a
VOH=0.975V
Vref1=0.675V
VOL= 0.375V
Δ=0.30V
Z0=40Ω
40Ω
2
80Ω
40Ω
8b
3
6b
(b)
DIMM
or
PCB
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=0.675V

FIG. 15

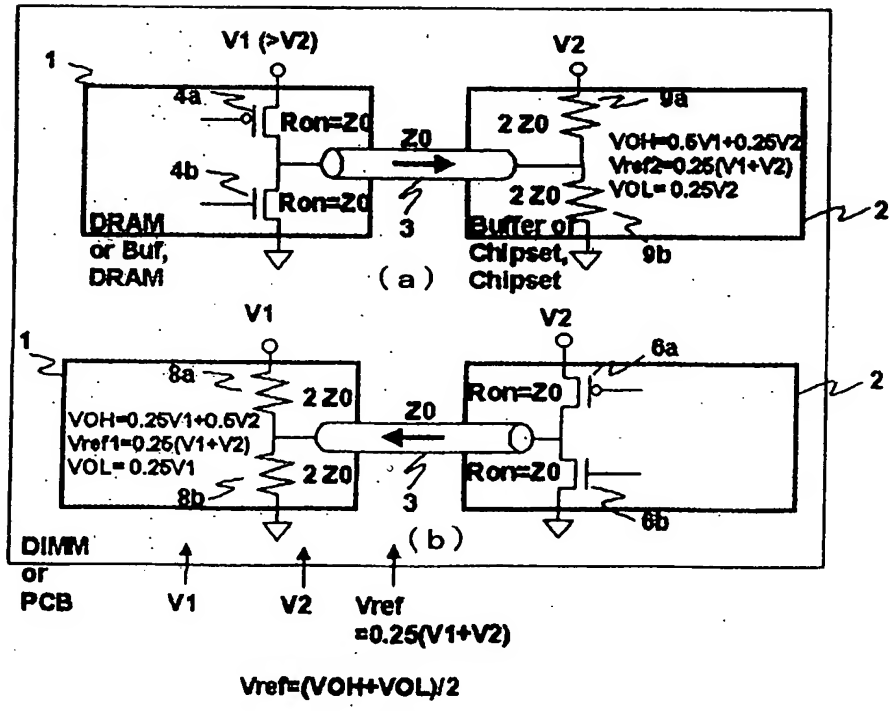

V1 (>V2)
V2
1
4a
Ron=Z0
Z0
2 Z0
9a
VOH=0.6V1+0.25V2
Vref2=0.25(V1+V2)
VOL= 0.25V2
4b
Ron=Z0
2 Z0
2
DRAM
or Buf,
DRAM
3
Buffer of
Chipset,
Chipset
9b
(a)
V1
V2
1
8a
2 Z0
6a
Ron=Z0
2
VOH=0.25V1+0.6V2
Vref1=0.25(V1+V2)
VOL= 0.25V1
Z0
2 Z0
Ron=Z0
8b
3
6b
(b)
DIMM
or
PCB
V1
V2
Vref
=0.25(V1+V2)
Vref=(VOH+VOL)/2

FIG. 16

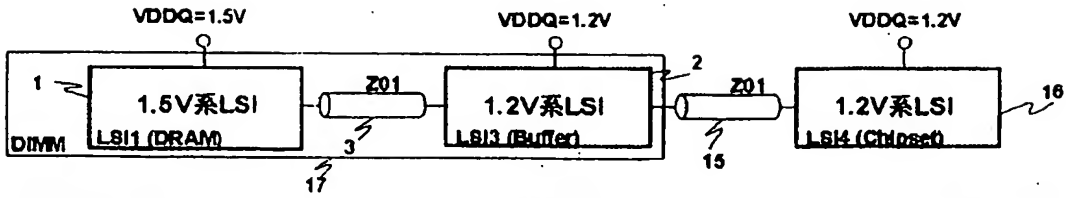


FIG. 17A

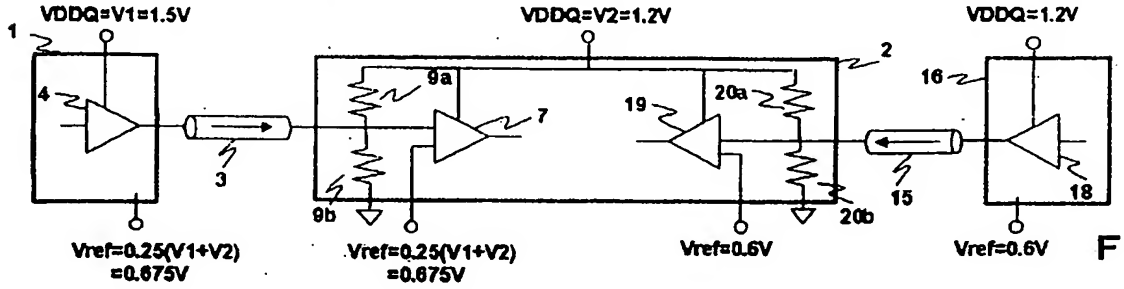


FIG. 17B

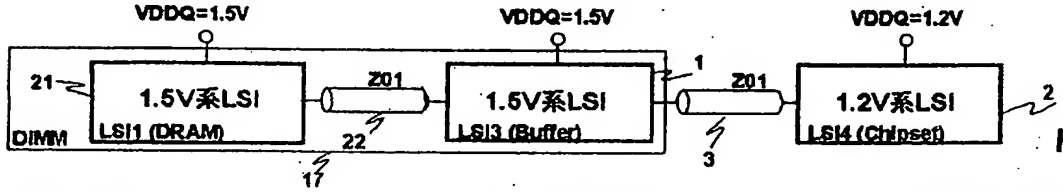


FIG. 18A

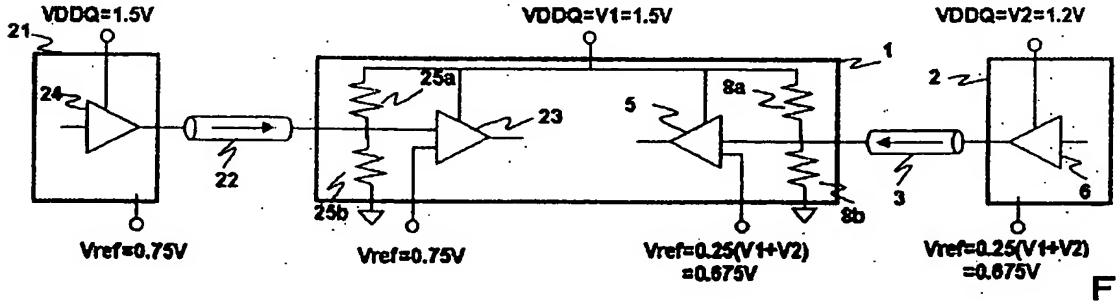


FIG. 18B

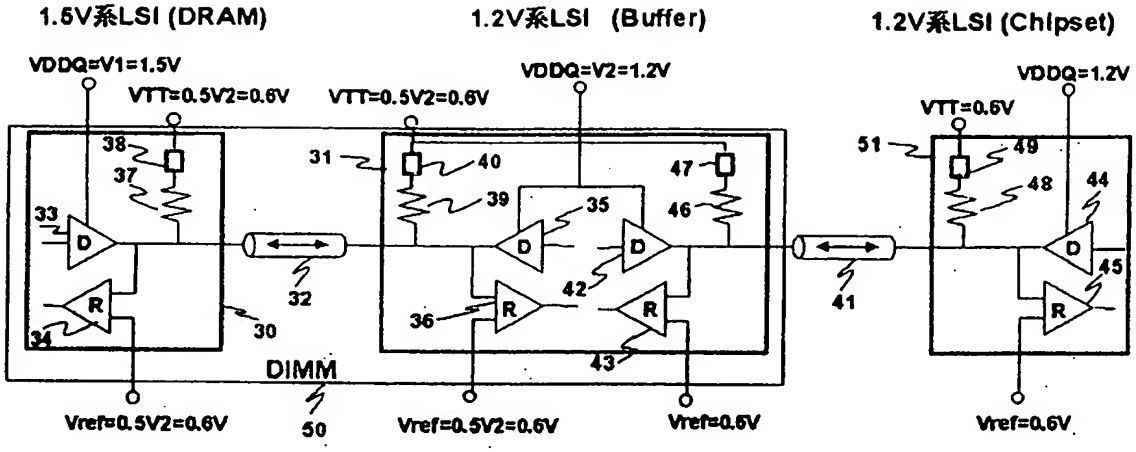

1.5V系LSI (DRAM)
1.2V系LSI (Buffer)
1.2V系LSI (Chipset)
VDDQ=V1=1.5V
VTT=0.5V2=0.6V
VTT=0.5V2=0.6V
VDDQ=V2=1.2V
VDDQ=1.2V
VTT=0.6V
38
37
33
D
R
34
30
32
31
40
39
47
35
46
D
D
42
36
R
R
43
DIMM
50
51
49
48
44
45
41
Vref=0.5V2=0.6V
Vref=0.5V2=0.6V
Vref=0.6V
Vref=0.6V

FIG. 19

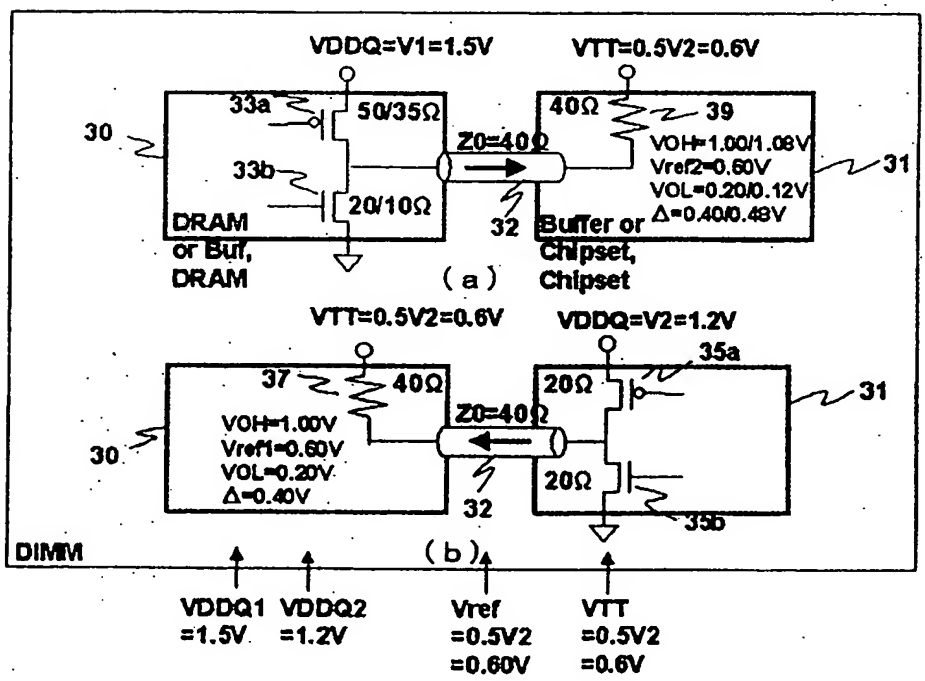
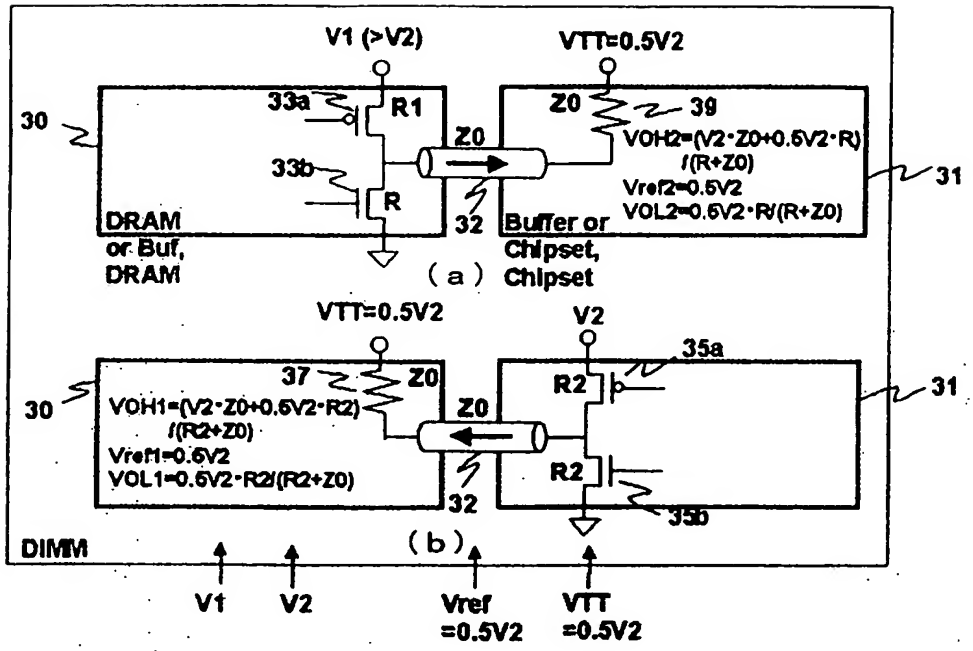

VDDQ=V1=1.5V
VTT=0.5V2=0.6V
33a
50/35Ω
30
Z0=40Ω
40Ω
39
VOH=1.00/1.08V
Vref2=0.60V
VOL=0.20/0.12V
Δ=0.40/0.48V
31
33b
20/10Ω
32
DRAM
or Buf,
DRAM
Buffer or
Chipset,
Chipset
(a)
VTT=0.5V2=0.6V
VDDQ=V2=1.2V
35a
37
40Ω
20Ω
31
Z0=40Ω
VOH=1.00V
Vref1=0.60V
VOL=0.20V
Δ=0.40V
30
20Ω
32
35b
DIMM
(b)
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=0.5V2
=0.60V
VTT
=0.5V2
=0.6V

FIG. 20



R1=2V1(R+Z0)/V2 - (2Z0+R)

FIG. 21

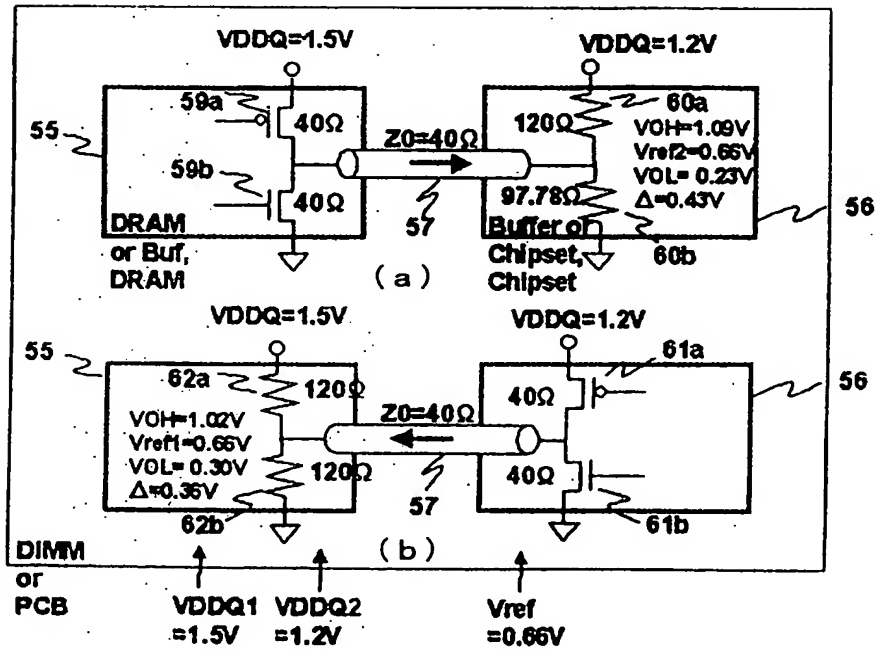
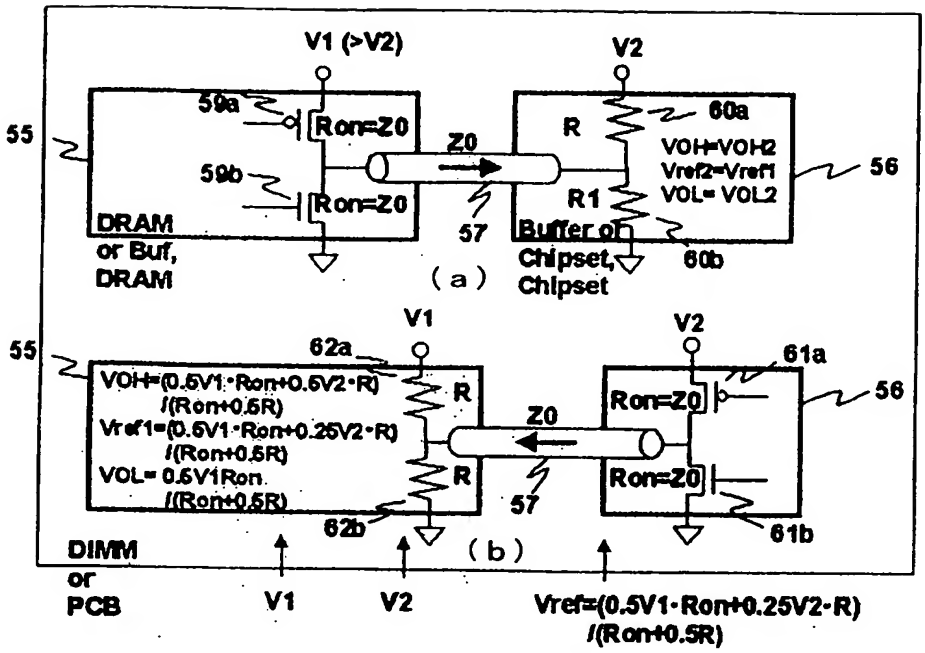


FIG. 22



$$R1=2R\cdot Ron(V1\cdot Ron+0.5V2-R)/(V2\cdot R\cdot Ron+R\cdot R\cdot V1+4Ron\cdot Ron\cdot V2-R\cdot R\cdot V2-2Ron\cdot Ron\cdot V1)$$

$$VOH2=(R\cdot R1\cdot V1+R1\cdot Ron\cdot V2)/(R\cdot R1+R1\cdot Ron+R\cdot Ron)$$

$$VOL2=R1\cdot Ron\cdot V2/(R\cdot R1+R\cdot Ron+R1\cdot Ron)$$

FIG. 23

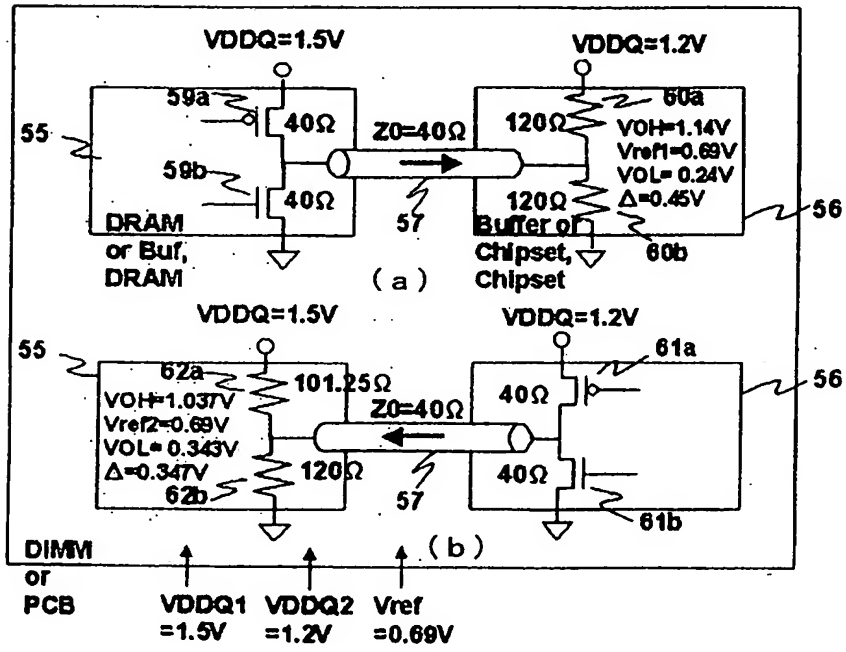


FIG. 24

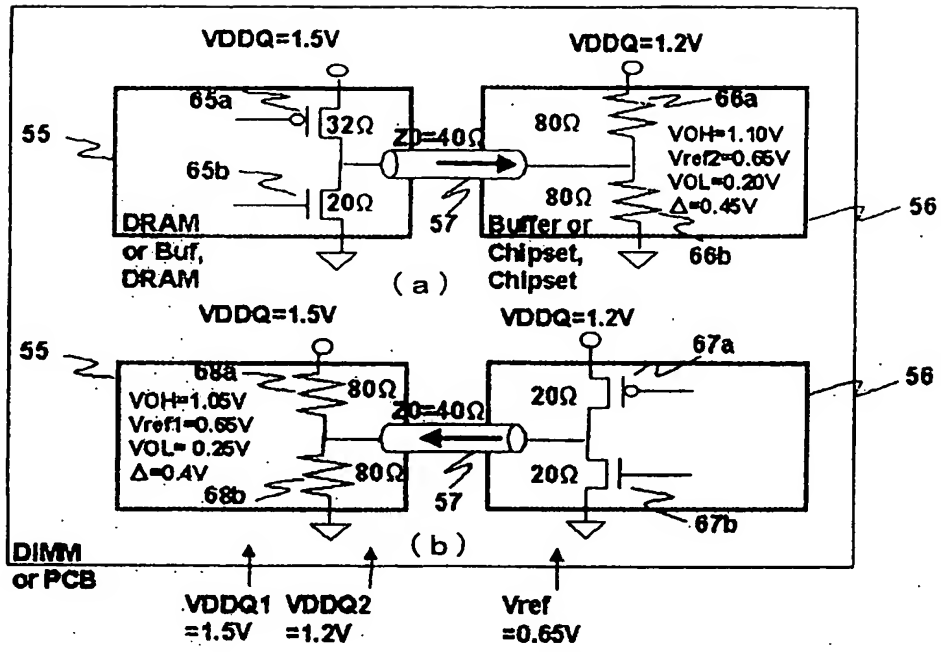
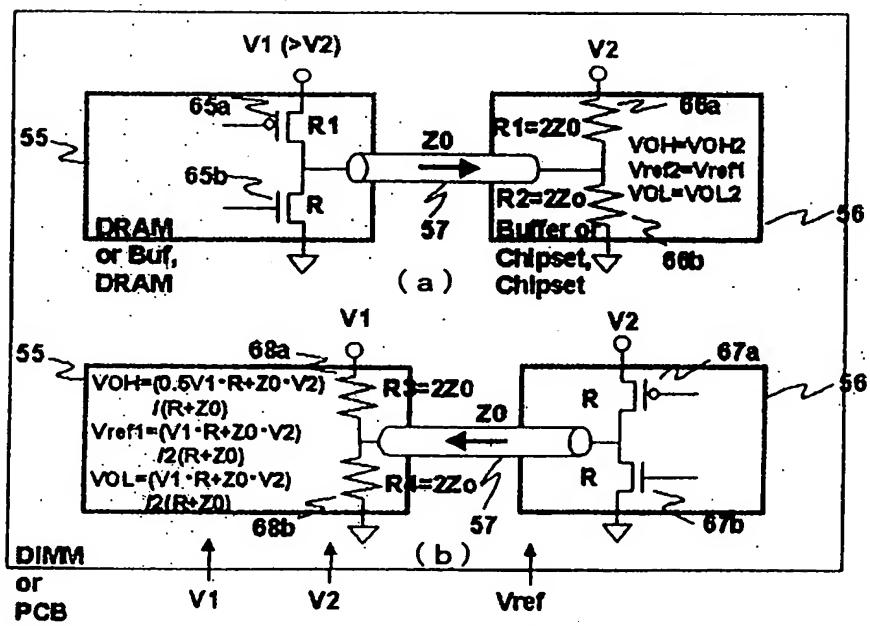


FIG. 25



$$R1=(V1\cdot Z0\cdot Z0-V2\cdot Z0\cdot Z0+0.5V2\cdot Z0\cdot R)/(V1\cdot R+0.5V2\cdot Z0-V2\cdot R)$$

$$VOH2=(0.5V2\cdot R1+V1\cdot Z0)/(R1+Z0)$$

$$VOL2=0.5V2\cdot R/(R+Z0)$$

FIG. 26

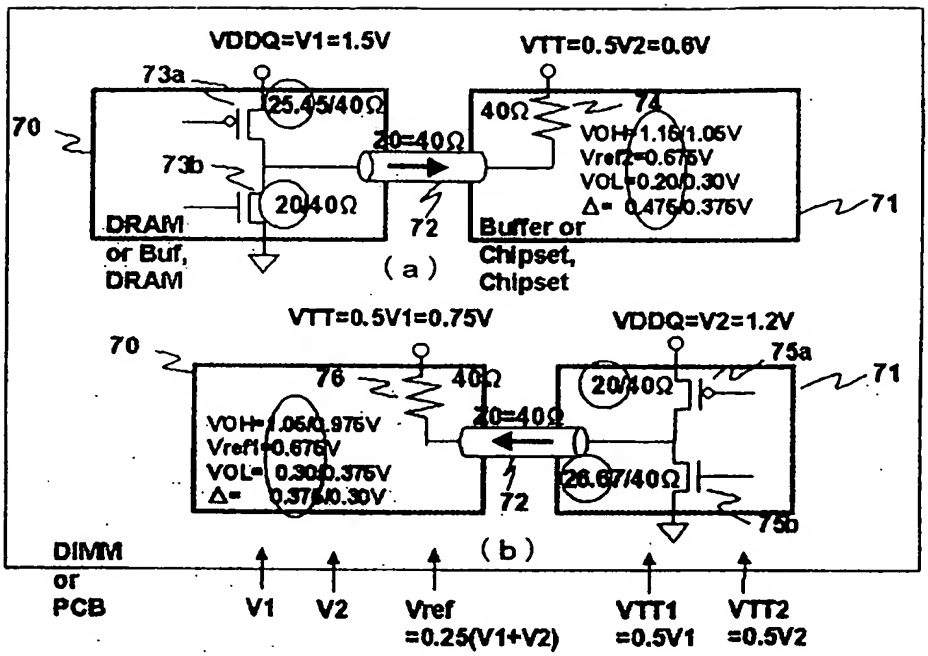

VDDQ=V1=1.5V
VTT=0.5V2=0.6V
73a
25.45/40Ω
70
40Ω
74
20=40Ω
VOH=1.16/1.05V
Vref2=0.675V
VOL=0.20/0.30V
Δ= 0.475/0.375V
73b
20/40Ω
71
DRAM
or Buf,
DRAM
72
Buffer or
Chipset,
Chipset
(a)
VTT=0.5V1=0.75V
VDDQ=V2=1.2V
70
75a
76
40Ω
71
20/40Ω
VOH=1.05/0.975V
Vref1=0.675V
VOL=0.30/0.375V
Δ= 0.375/0.30V
20=40Ω
26.67/40Ω
72
75b
DIMM
or
PCB
(b)
V1
V2
Vref
=0.25(V1+V2)
VTT1
=0.5V1
VTT2
=0.5V2

FIG. 27

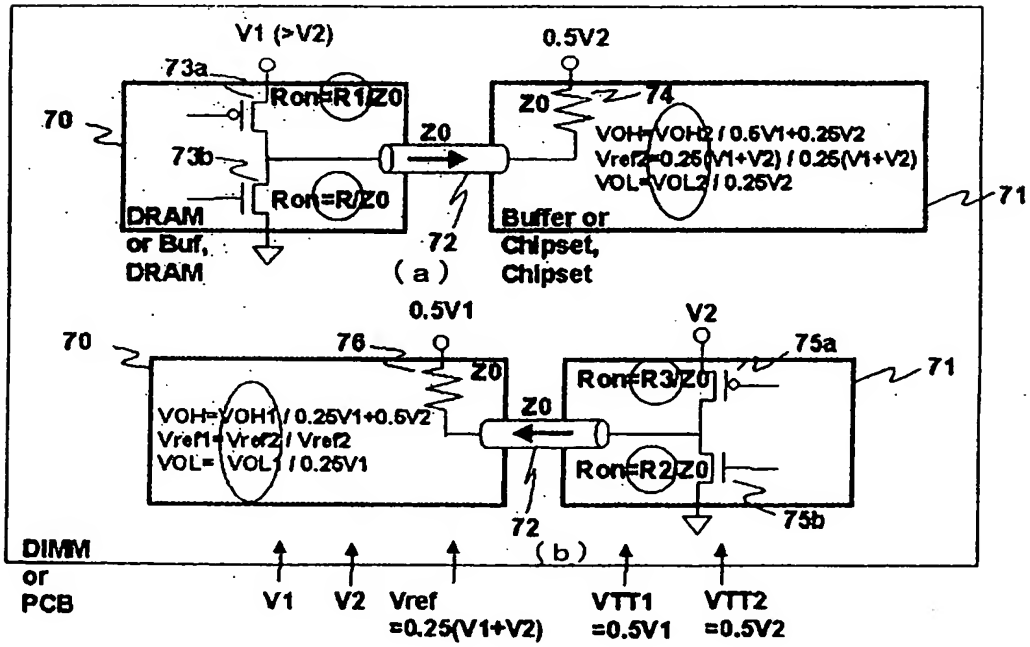

V1 (>V2)
0.5V2
73a
Ron=R1/Z0
70
Z0
74
Z0
VOH=VOH2 / 0.5V1+0.25V2
Vref2=0.25(V1+V2) / 0.25(V1+V2)
VOL=VOL2 / 0.25V2
73b
Ron=R/Z0
71
DRAM
or Buf,
DRAM
72
Buffer or
Chipset,
Chipset
(a)
0.5V1
V2
70
76
75a
Z0
Ron=R3/Z0
71
VOH=VOH1 / 0.25V1+0.5V2
Vref1=Vref2 / Vref2
VOL=VOL1 / 0.25V1
Z0
Ron=R2/Z0
72
75b
DIMM
or
PCB
(b)
V1
V2
Vref
=0.25(V1+V2)
VTT1
=0.5V1
VTT2
=0.5V2

FIG. 28

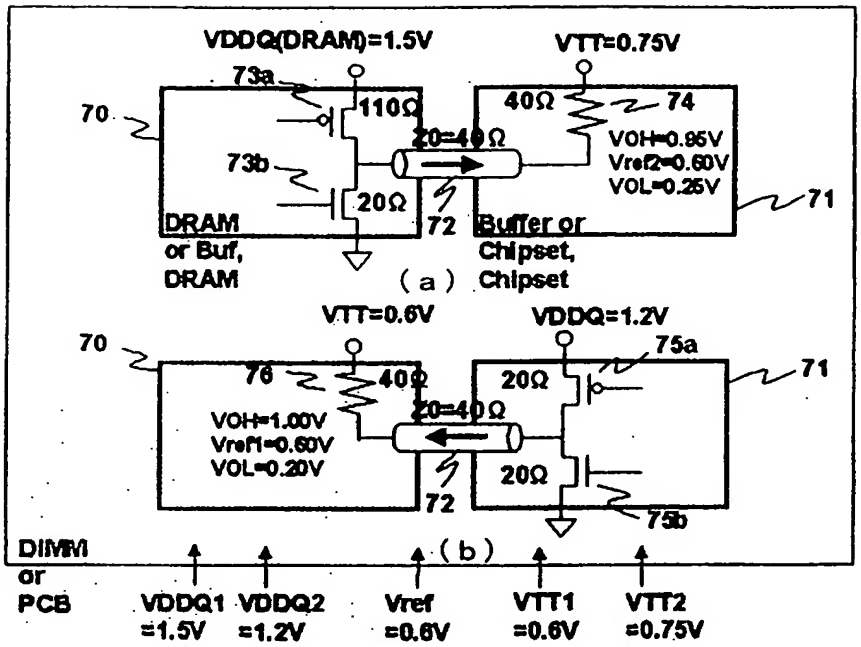

VDDQ(DRAM)=1.5V
VTT=0.75V
73a
110Ω
40Ω
74
70
Z0=40Ω
VOH=0.95V
Vref2=0.60V
VOL=0.25V
73b
20Ω
71
72
DRAM
or Buf,
DRAM
Buffer or
Chipset,
Chipset
(a)
VTT=0.6V
VDDQ=1.2V
70
75a
76
40Ω
20Ω
71
VOH=1.00V
Vref1=0.60V
VOL=0.20V
Z0=40Ω
20Ω
72
75b
DIMM
or
PCB
(b)
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=0.6V
VTT1
=0.6V
VTT2
=0.75V

FIG. 29

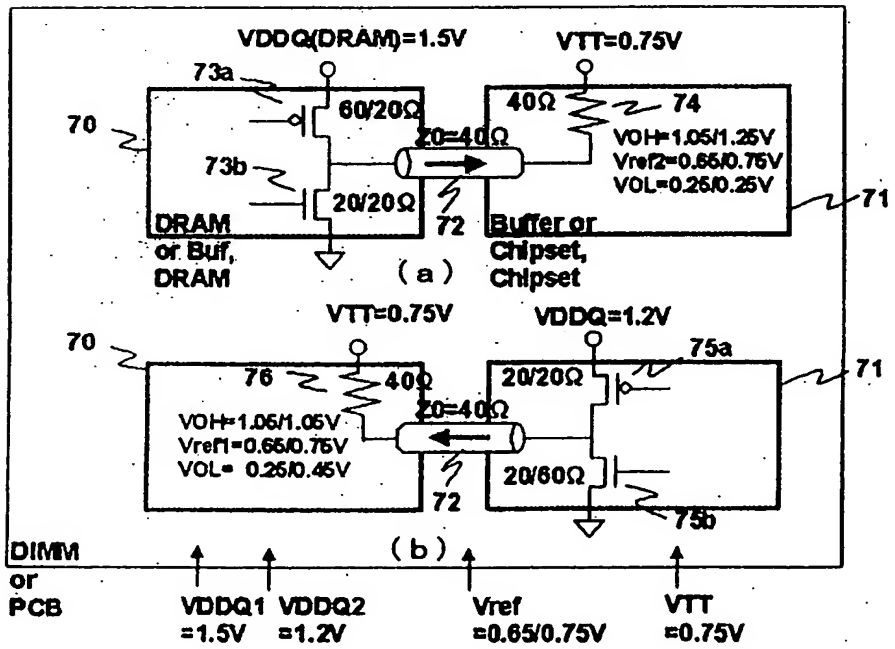
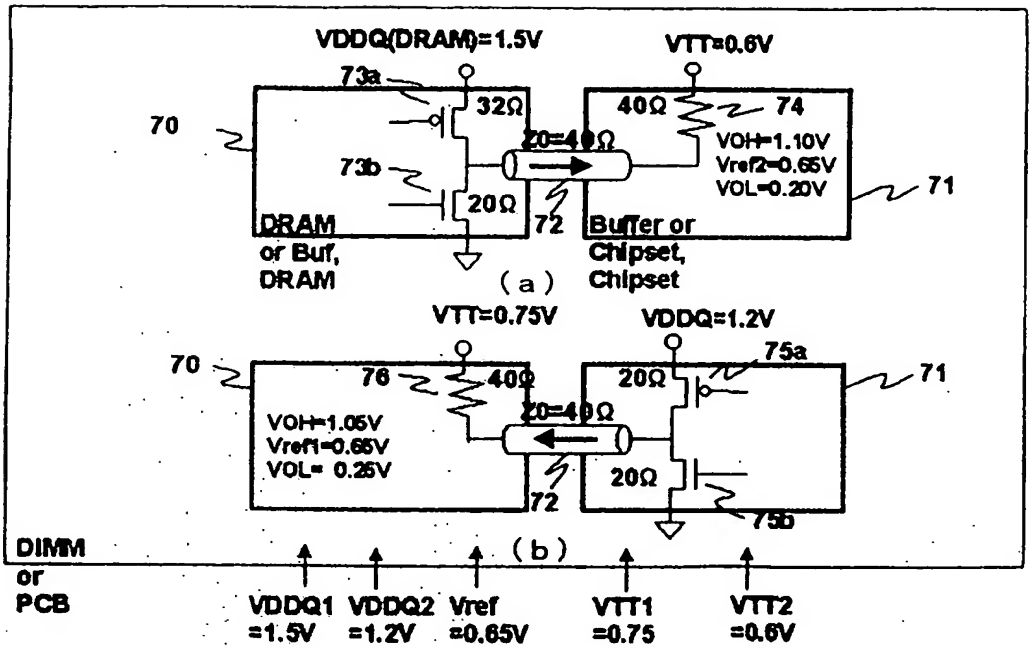
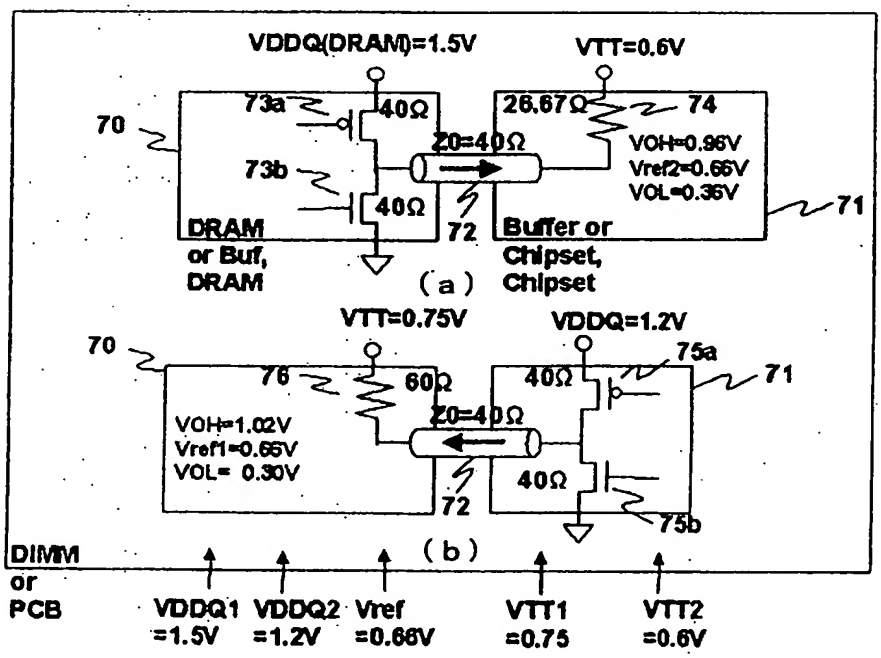

VDDQ(DRAM)=1.5V
VTT=0.75V
73a
60/20Ω
40Ω
74
70
Z0=40Ω
VOH=1.05/1.25V
Vref2=0.65/0.75V
VOL=0.25/0.25V
73b
20/20Ω
71
72
DRAM
or Buf,
DRAM
Buffer or
Chipset,
Chipset
(a)
VTT=0.75V
VDDQ=1.2V
70
75a
76
40Ω
20/20Ω
71
VOH=1.05/1.05V
Vref1=0.65/0.75V
VOL= 0.25/0.45V
Z0=40Ω
20/60Ω
72
75b
DIMM
or
PCB
(b)
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=0.65/0.75V
VTT
=0.75V

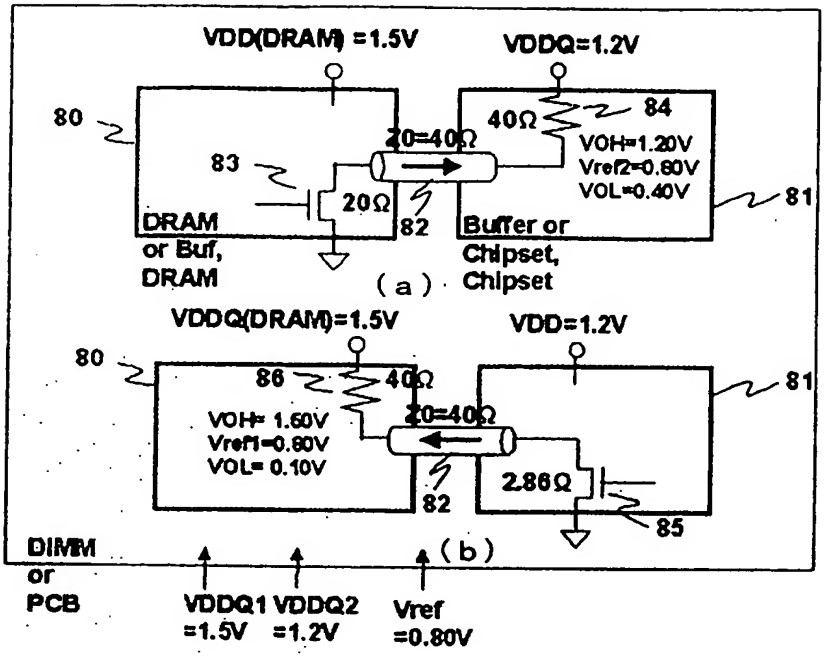
FIG. 30


VDDQ(DRAM)=1.5V
VTT=0.6V
73a
32Ω
40Ω
74
70
Z0=40Ω
VOH=1.10V
Vref2=0.65V
VOL=0.20V
73b
71
20Ω
72
DRAM
or Buf,
DRAM
Buffer or
Chipset,
Chipset
(a)
VTT=0.75V
VDDQ=1.2V
70
76
40Ω
20Ω
75a
71
Z0=40Ω
VOH=1.05V
Vref1=0.65V
VOL= 0.25V
20Ω
72
75b
DIMM
or
PCB
(b)
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=0.65V
VTT1
=0.75
VTT2
=0.6V

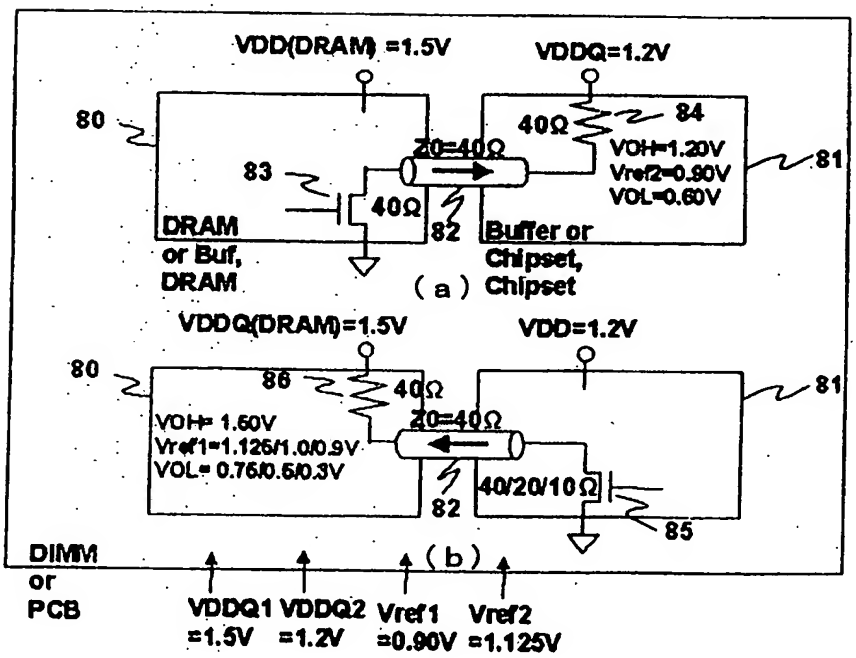
F I G. 3 1


VDDQ(DRAM)=1.5V
VTT=0.6V
73a
40Ω
26.67Ω
74
70
Z0=40Ω
VOH=0.96V
Vref2=0.66V
VOL=0.36V
73b
71
40Ω
72
DRAM
or Buf,
DRAM
Buffer or
Chipset,
Chipset
(a)
VTT=0.75V
VDDQ=1.2V
70
76
60Ω
40Ω
75a
71
Z0=40Ω
VOH=1.02V
Vref1=0.66V
VOL= 0.30V
40Ω
72
75b
DIMM
or
PCB
(b)
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=0.66V
VTT1
=0.75
VTT2
=0.6V

F I G. 3 2


VDD(DRAM) =1.5V
VDDQ=1.2V
80
40Ω
84
Z0=40Ω
VOH=1.20V
Vref2=0.60V
VOL=0.40V
83
20Ω
82
81
DRAM
or Buf,
DRAM
Buffer or
Chipset,
Chipset
(a)
VDDQ(DRAM)=1.5V
VDD=1.2V
80
86
40Ω
81
VOH= 1.60V
Vref1=0.80V
VOL= 0.10V
Z0=40Ω
2.86Ω
82
85
DIMM
or
PCB
(b)
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=0.80V

F I G. 3 3


VDD(DRAM) =1.5V
VDDQ=1.2V
80
40Ω
84
Z0=40Ω
VOH=1.20V
Vref2=0.90V
VOL=0.60V
81
83
40Ω
82
DRAM
or Buf,
DRAM
Buffer or
Chipset,
(a) Chipset
VDDQ(DRAM)=1.5V
VDD=1.2V
80
86
40Ω
81
VOH= 1.60V
Vref1=1.125/1.0/0.9V
VOL= 0.76/0.6/0.3V
Z0=40Ω
40/20/10Ω
82
85
DIMM
or
PCB
(b)
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref1
=0.90V
Vref2
=1.125V

F I G. 3 4

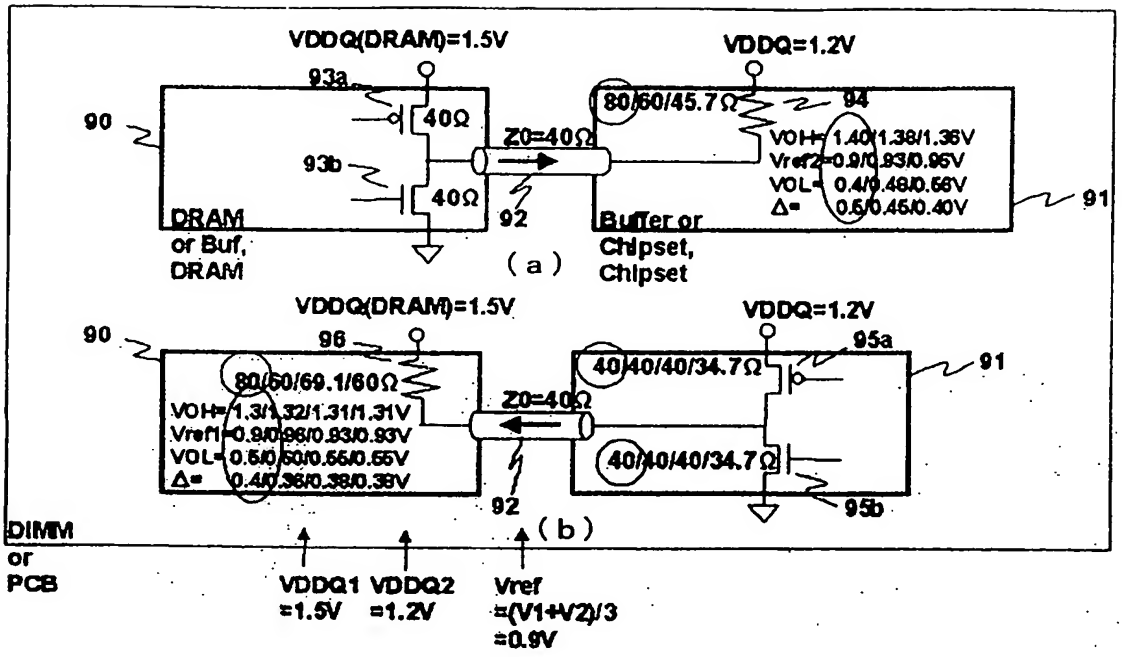

VDDQ(DRAM)=1.5V
VDDQ=1.2V
93a
90
40Ω
Z0=40Ω
80/60/45.7Ω
94
VOH= 1.40/1.38/1.36V
Vref2=0.9/0.93/0.95V
VOL= 0.4/0.48/0.56V
Δ= 0.5/0.45/0.40V
91
93b
40Ω
92
DRAM
or Buf,
DRAM
(a)
Buffer or
Chipset,
Chipset
VDDQ(DRAM)=1.5V
VDDQ=1.2V
90
96
95a
80/60/69.1/60Ω
40/40/40/34.7Ω
91
VOH= 1.3/1.32/1.31/1.31V
Vref1=0.9/0.96/0.93/0.93V
VOL= 0.5/0.60/0.66/0.55V
Δ= 0.4/0.36/0.38/0.38V
Z0=40Ω
40/40/40/34.7Ω
92
95b
(b)
DIMM
or
PCB
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=(V1+V2)/3
=0.9V

FIG. 35

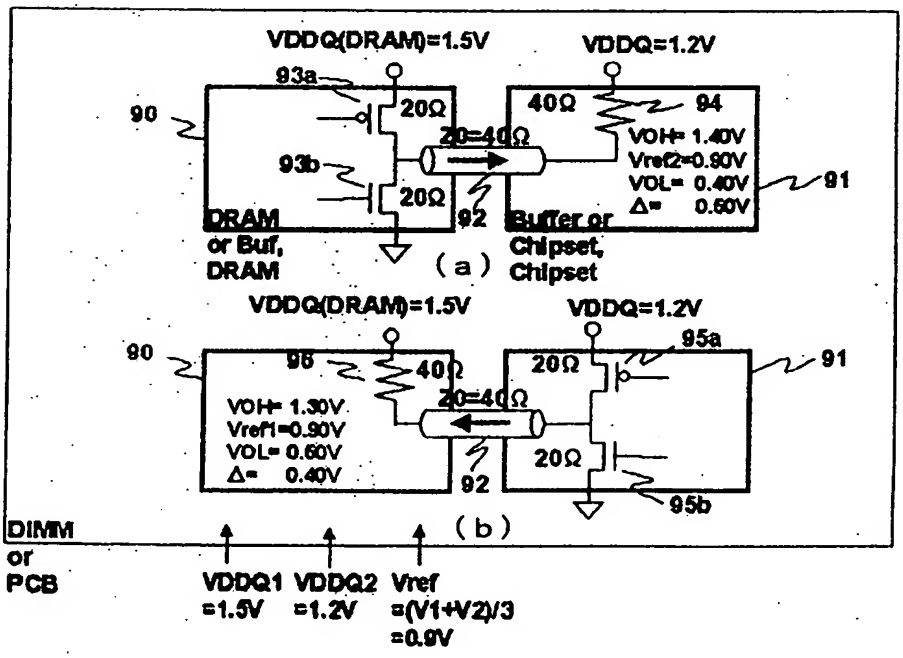

VDDQ(DRAM)=1.5V
VDDQ=1.2V
93a
90
20Ω
40Ω
94
Z0=40Ω
VOH= 1.40V
Vref2=0.90V
VOL= 0.40V
Δ= 0.60V
91
93b
20Ω
92
DRAM
or Buf,
DRAM
(a)
Buffer or
Chipset,
Chipset
VDDQ(DRAM)=1.5V
VDDQ=1.2V
90
96
40Ω
95a
20Ω
91
Z0=40Ω
VOH= 1.30V
Vref1=0.90V
VOL= 0.60V
Δ= 0.40V
20Ω
92
95b
(b)
DIMM
or
PCB
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref
=(V1+V2)/3
=0.9V

FIG. 36

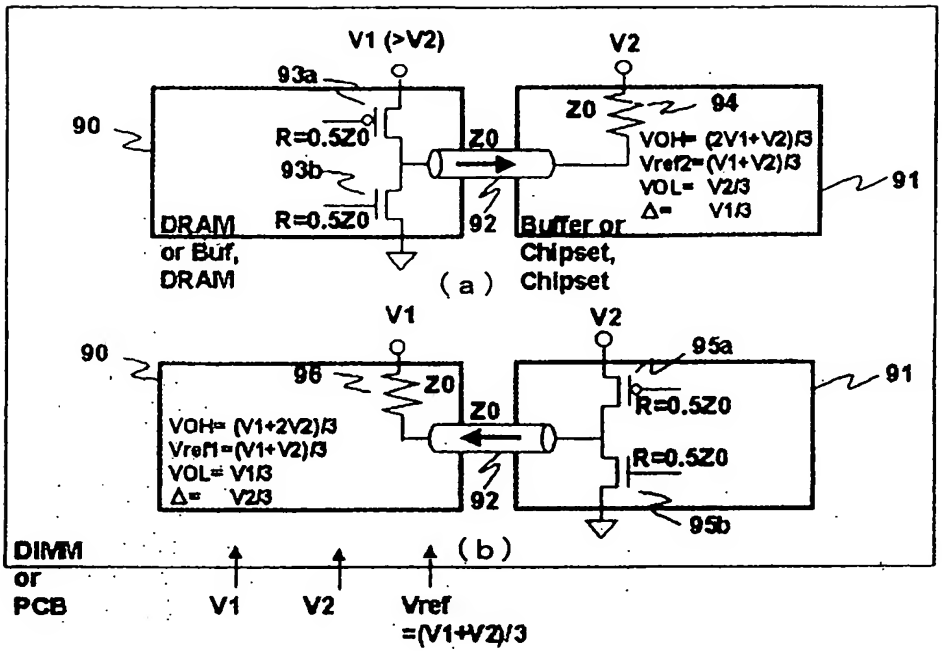


FIG. 37

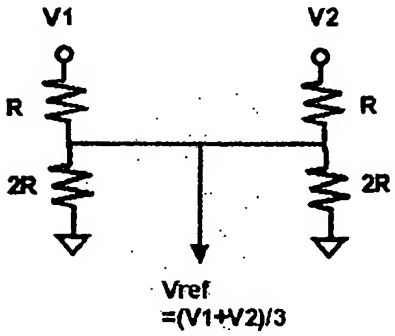


FIG. 38A

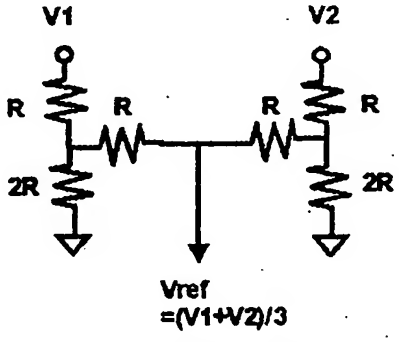


FIG. 38B

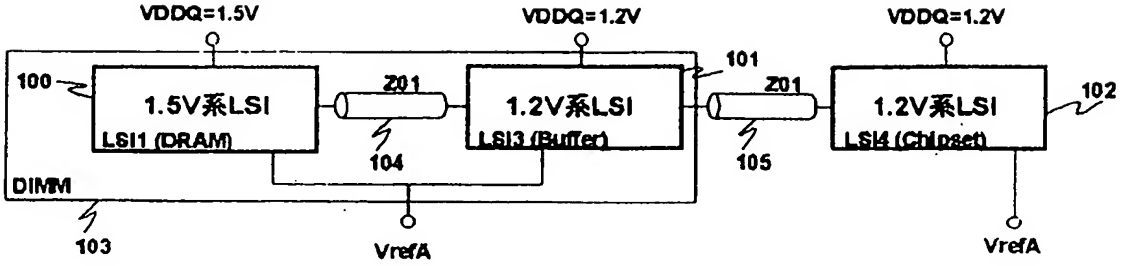

VDDQ=1.5V
VDDQ=1.2V
VDDQ=1.2V
100
1.5V系LSI
LSI1 (DRAM)
Z01
1.2V系LSI
LSI3 (Buffer)
101
Z01
1.2V系LSI
LSI4 (Chipset)
102
104
105
DIMM
103
VrefA
VrefA

FIG. 39

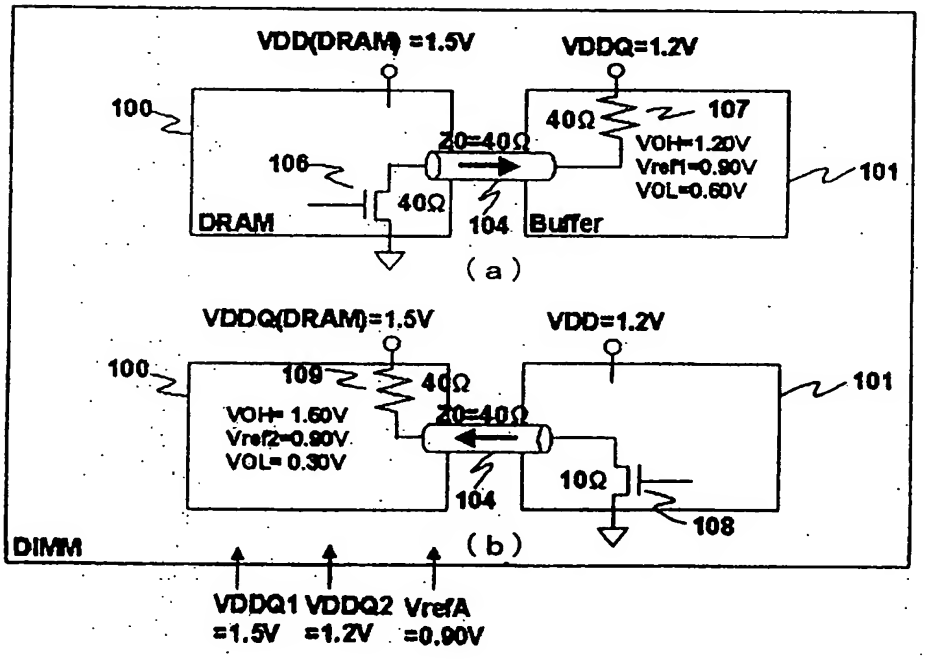

VDD(DRAM) =1.5V
VDDQ=1.2V
100
40Ω
107
Z0=40Ω
VOH=1.20V
Vref1=0.90V
VOL=0.60V
101
106
40Ω
DRAM
104
Buffer
(a)
VDDQ(DRAM)=1.5V
VDD=1.2V
100
109
40Ω
VOH= 1.60V
Vref2=0.90V
VOL= 0.30V
Z0=40Ω
101
10Ω
104
108
DIMM
(b)
VDDQ1 VDDQ2 VrefA
=1.5V =1.2V =0.90V

FIG. 40

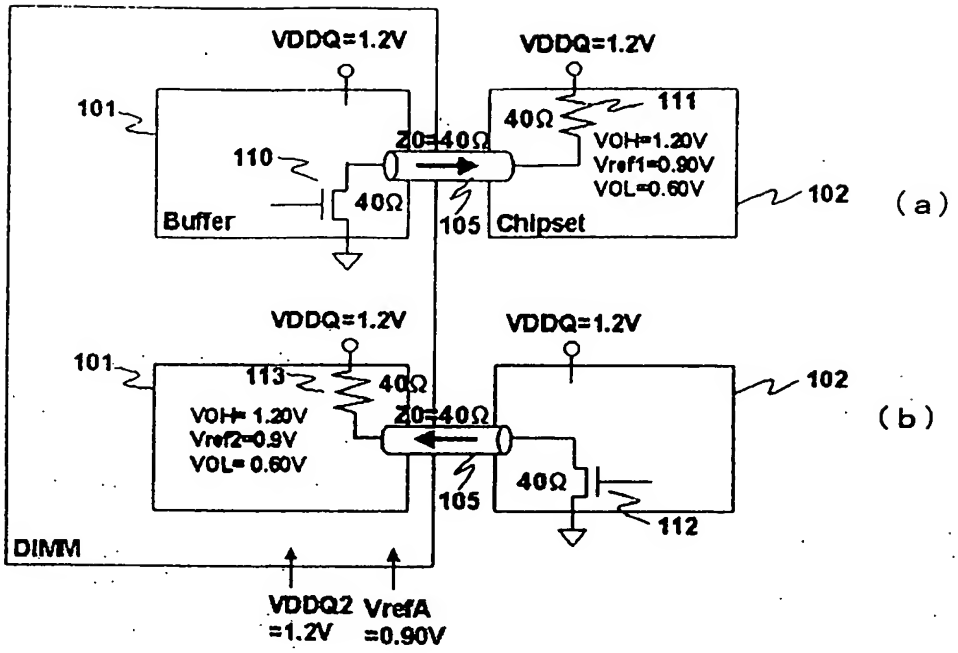

VDDQ=1.2V
VDDQ=1.2V
101
40Ω
111
Z0=40Ω
VOH=1.20V
Vref1=0.90V
VOL=0.60V
110
40Ω
Buffer
105
Chipset
102
(a)
VDDQ=1.2V
VDDQ=1.2V
101
113
40Ω
VOH= 1.20V
Vref2=0.9V
VOL= 0.60V
Z0=40Ω
102
(b)
105
40Ω
112
DIMM
VDDQ2
=1.2V
VrefA
=0.90V

FIG. 41

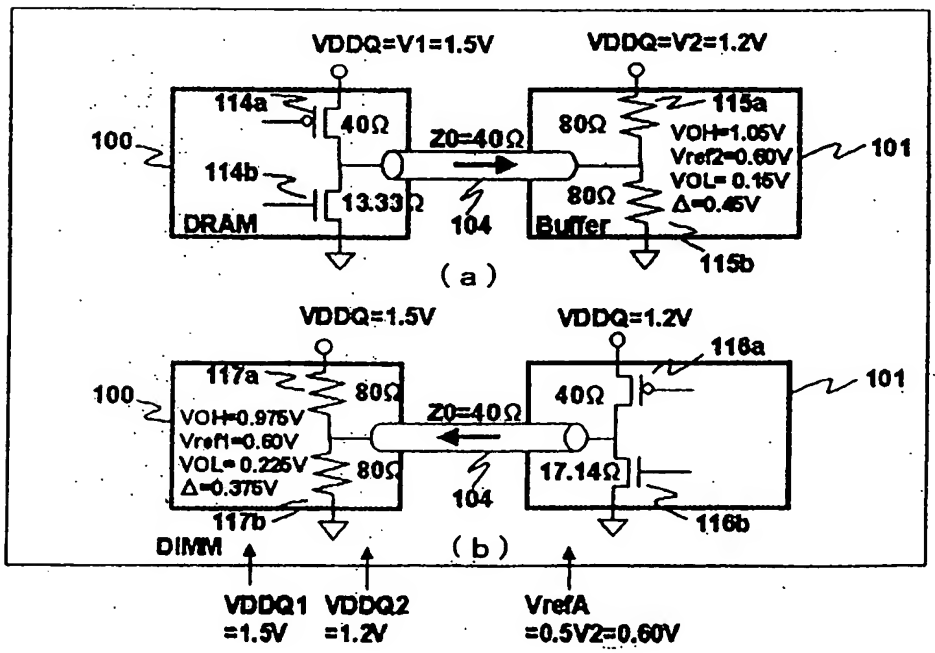

VDDQ=V1=1.5V
VDDQ=V2=1.2V
114a
40Ω
Z0=40Ω
80Ω
115a
VOH=1.05V
Vref2=0.60V
VOL= 0.15V
Δ=0.45V
100
114b
13.33Ω
104
80Ω
101
DRAM
Buffer
115b
(a)
VDDQ=1.5V
VDDQ=1.2V
117a
80Ω
116a
100
VOH=0.975V
Vref1=0.60V
VOL= 0.225V
Δ=0.375V
Z0=40Ω
40Ω
101
80Ω
17.14Ω
104
117b
116b
DIMM
(b)
VDDQ1
=1.5V
VDDQ2
=1.2V
VrefA
=0.5V2=0.60V

FIG. 42

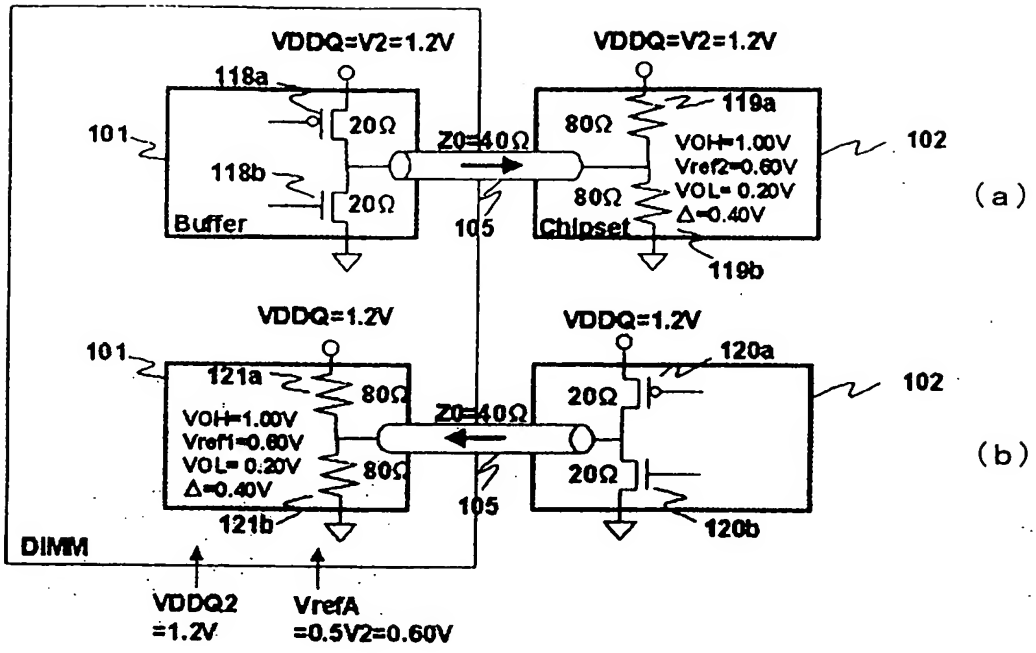

VDDQ=V2=1.2V
VDDQ=V2=1.2V
118a
119a
101
20Ω
Z0=40Ω
80Ω
VOH=1.00V
Vref2=0.60V
102
118b
20Ω
80Ω
VOL= 0.20V
Δ=0.40V
Buffer
105
Chipset
119b
(a)
VDDQ=1.2V
VDDQ=1.2V
101
120a
121a
80Ω
20Ω
102
VOH=1.00V
Vref1=0.60V
VOL= 0.20V
Δ=0.40V
Z0=40Ω
80Ω
20Ω
105
(b)
121b
120b
DIMM
VDDQ2
=1.2V
VrefA
=0.5V2=0.60V

FIG. 43

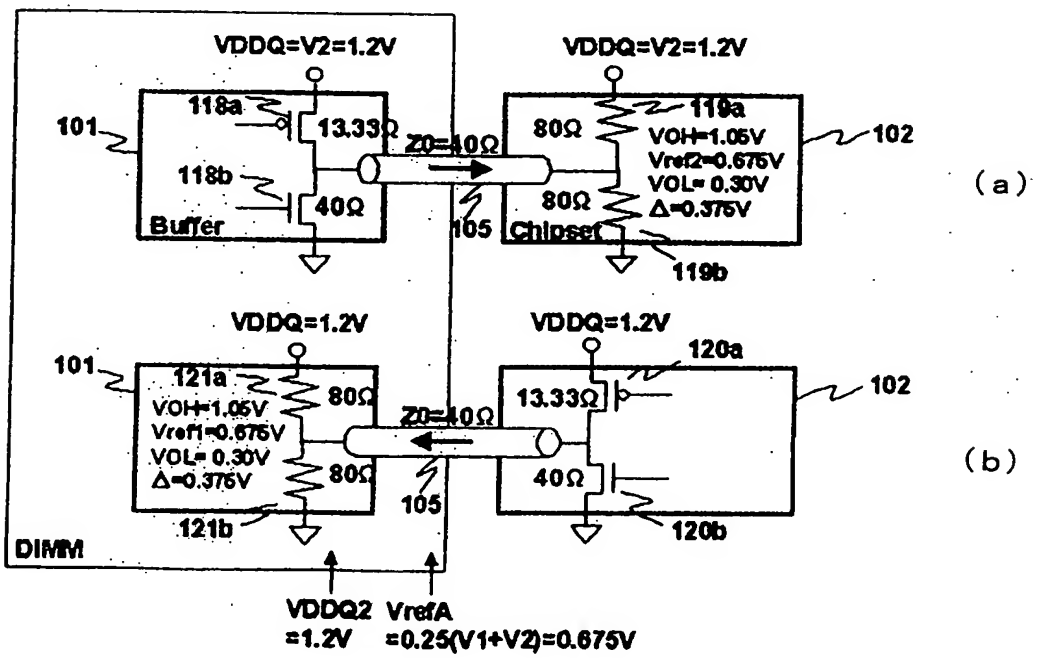

VDDQ=V2=1.2V
VDDQ=V2=1.2V
118a
119a
101
13.33Ω
Z0=40Ω
80Ω
VOH=1.05V
Vref2=0.675V
102
118b
40Ω
80Ω
VOL= 0.30V
Δ=0.375V
Buffer
105
Chipset
119b
(a)
VDDQ=1.2V
VDDQ=1.2V
101
120a
121a
80Ω
13.33Ω
102
VOH=1.05V
Vref1=0.675V
VOL= 0.30V
Δ=0.375V
Z0=40Ω
80Ω
40Ω
105
(b)
121b
120b
DIMM
VDDQ2
=1.2V
VrefA
=0.25(V1+V2)=0.675V

FIG. 44

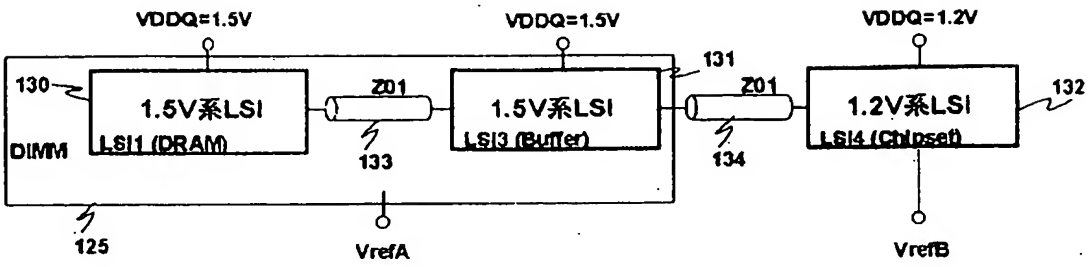

VDDQ=1.5V
VDDQ=1.5V
VDDQ=1.2V
130
1.5V系LSI
LSI1 (DRAM)
DIMM
Z01
133
1.5V系LSI
LSI3 (Buffer)
131
Z01
134
1.2V系LSI
LSI4 (Chipset)
132
125
VrefA
VrefB

FIG. 45

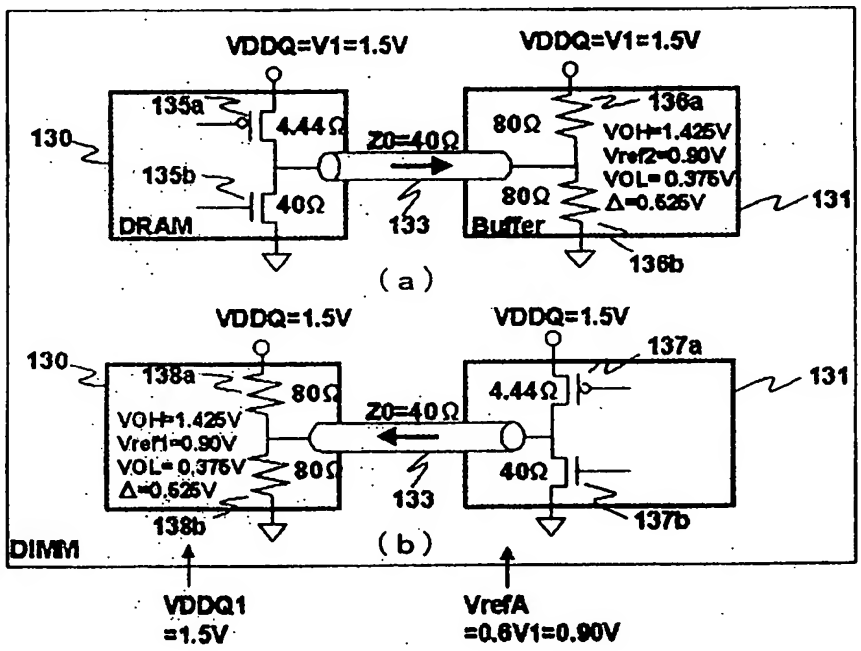

VDDQ=V1=1.5V
VDDQ=V1=1.5V
135a
4.44Ω
130
Z0=40Ω
80Ω
136a
VOH=1.425V
Vref2=0.90V
VOL=0.375V
Δ=0.525V
135b
40Ω
80Ω
131
DRAM
133
Buffer
136b
(a)
VDDQ=1.5V
VDDQ=1.5V
137a
130
138a
80Ω
4.44Ω
131
VOH=1.425V
Vref1=0.90V
VOL=0.375V
Δ=0.525V
Z0=40Ω
80Ω
40Ω
133
138b
137b
(b)
DIMM
VDDQ1
=1.5V
VrefA
=0.6V1=0.90V

FIG. 46

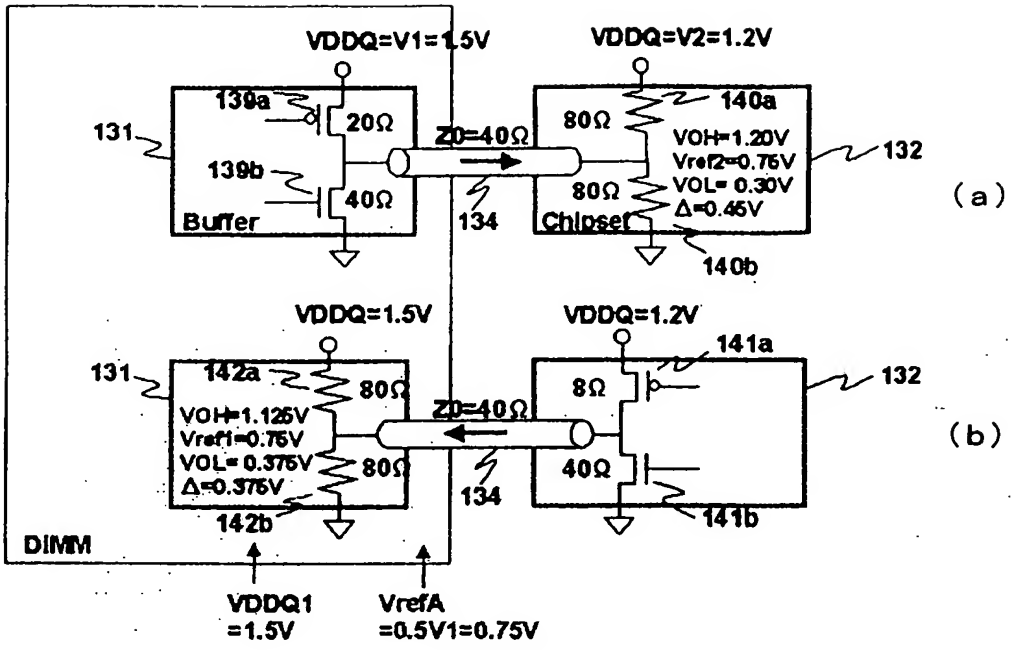

VDDQ=V1=1.5V
VDDQ=V2=1.2V
139a
20Ω
131
Z0=40Ω
80Ω
140a
VOH=1.20V
Vref2=0.75V
132
139b
40Ω
80Ω
VOL= 0.30V
Δ=0.45V
Buffer
134
Chipset
140b
(a)
VDDQ=1.5V
VDDQ=1.2V
141a
131
142a
80Ω
8Ω
132
VOH=1.125V
Vref1=0.75V
VOL= 0.375V
Δ=0.375V
Z0=40Ω
80Ω
40Ω
134
(b)
142b
141b
DIMM
VDDQ1
=1.5V
VrefA
=0.5V1=0.75V

FIG. 47

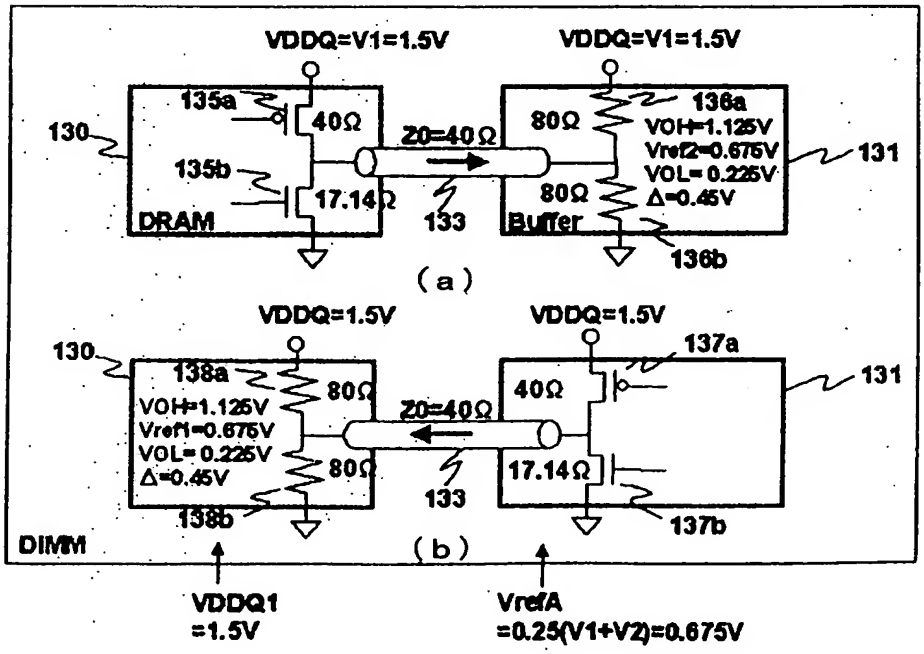

VDDQ=V1=1.5V
VDDQ=V1=1.5V
135a
40Ω
136a
130
Z0=40Ω
80Ω
VOH=1.125V
Vref2=0.675V
131
135b
VOL= 0.225V
17.14Ω
80Ω
Δ=0.45V
DRAM
133
Buffer
136b
(a)
VDDQ=1.5V
VDDQ=1.5V
137a
130
138a
80Ω
40Ω
131
VOH=1.125V
Vref1=0.675V
Z0=40Ω
VOL= 0.225V
Δ=0.45V
80Ω
17.14Ω
133
138b
137b
DIMM
(b)
VDDQ1
=1.5V
VrefA
=0.25(V1+V2)=0.675V

FIG. 48

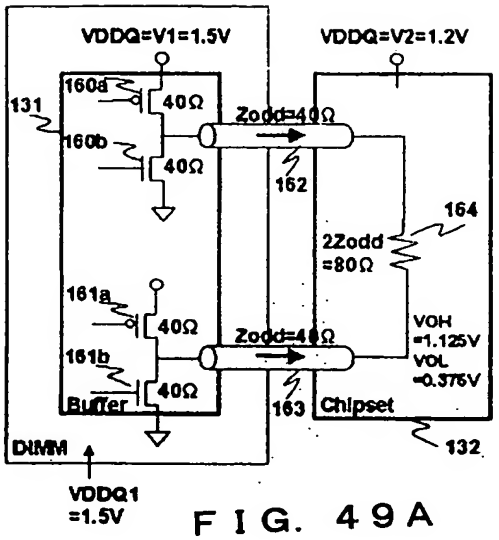


FIG. 49A

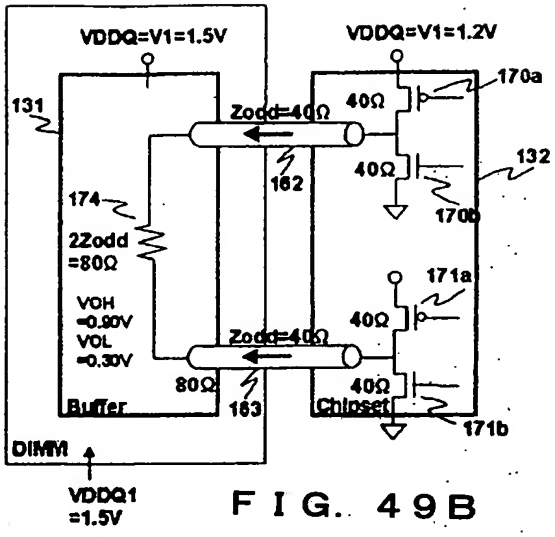
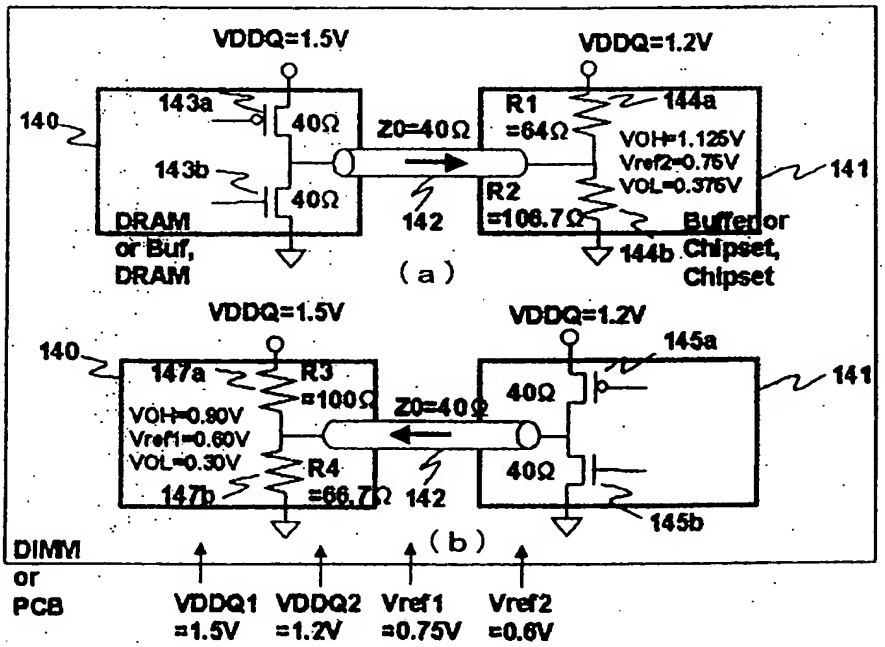
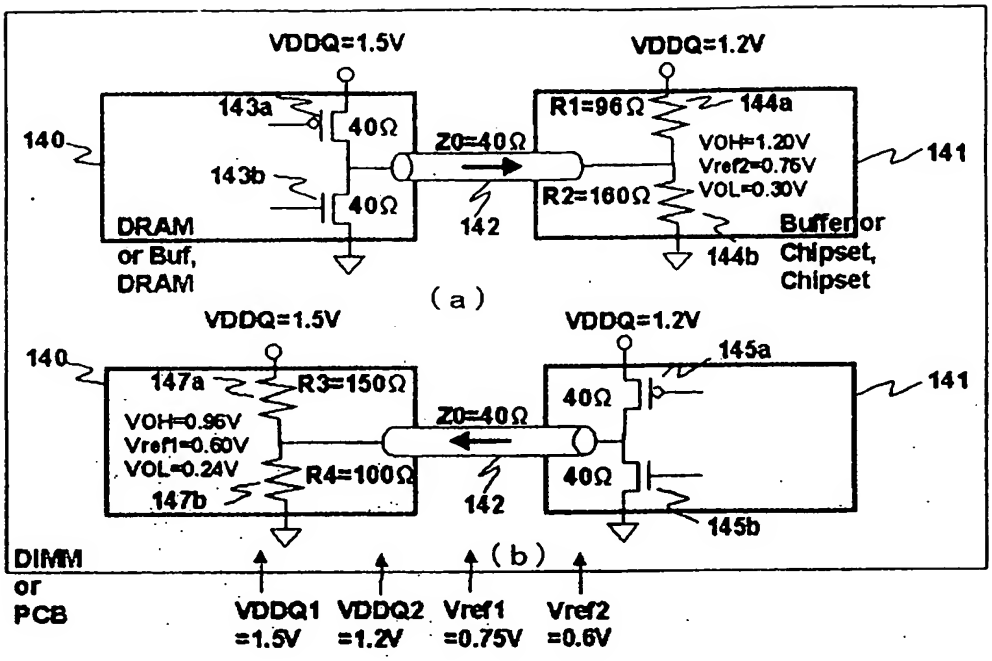


FIG. 49B



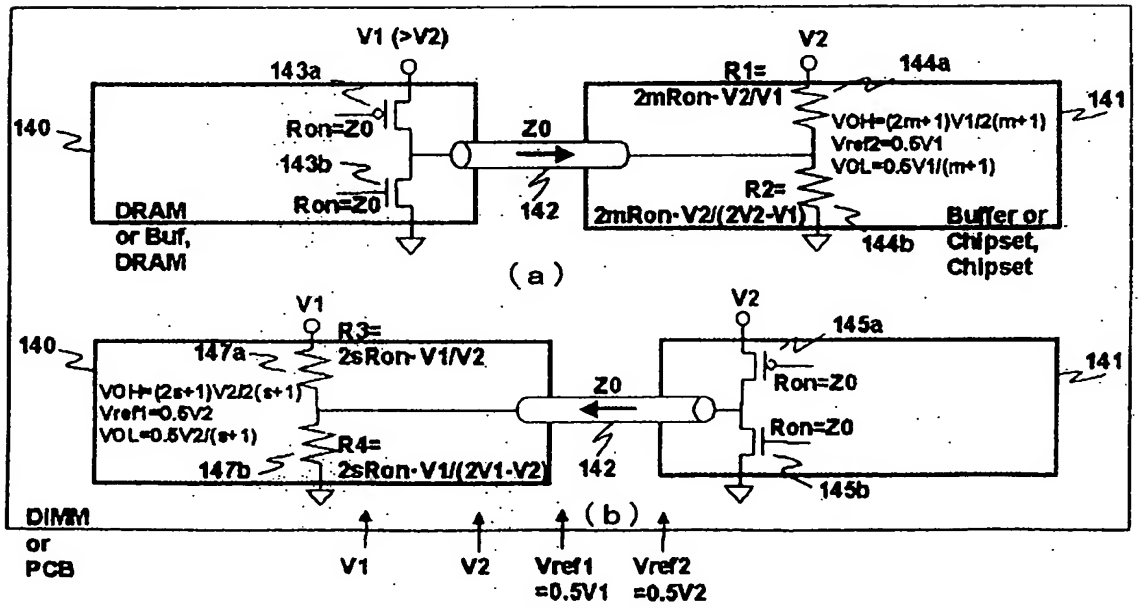
m=(R1//R2)/Z0=s=(R3//R4)/Z0=1.0

FIG. 50



m=(R1//R2)/Z0=s=(R3//R4)/Z0=1.5

FIG. 51



m=(R1//R2)/Z0
s=(R3//R4)/Z0

FIG. 52

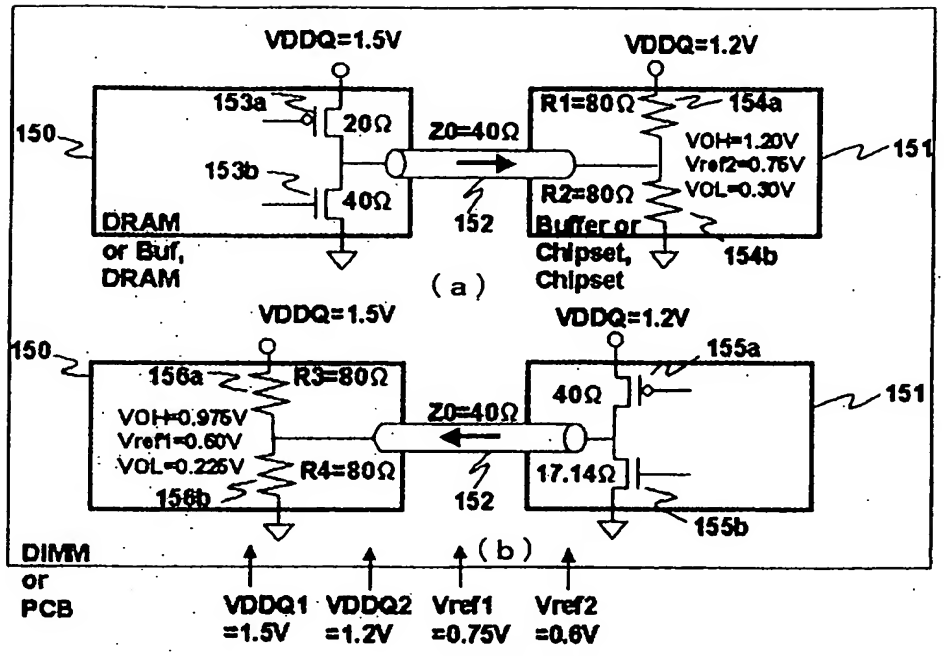

VDDQ=1.5V
VDDQ=1.2V
153a
20Ω
Z0=40Ω
R1=80Ω
154a
150
VOH=1.20V
Vref2=0.75V
151
153b
40Ω
R2=80Ω
VOL=0.30V
152
DRAM
or Buf,
DRAM
Buffer or
Chipset,
Chipset
154b
(a)
VDDQ=1.5V
VDDQ=1.2V
150
155a
156a
R3=80Ω
40Ω
151
VOH=0.975V
Vref1=0.60V
Z0=40Ω
VOL=0.225V
R4=80Ω
17.14Ω
156b
152
155b
DIMM
or
PCB
(b)
VDDQ1
=1.5V
VDDQ2
=1.2V
Vref1
=0.75V
Vref2
=0.6V

FIG. 53

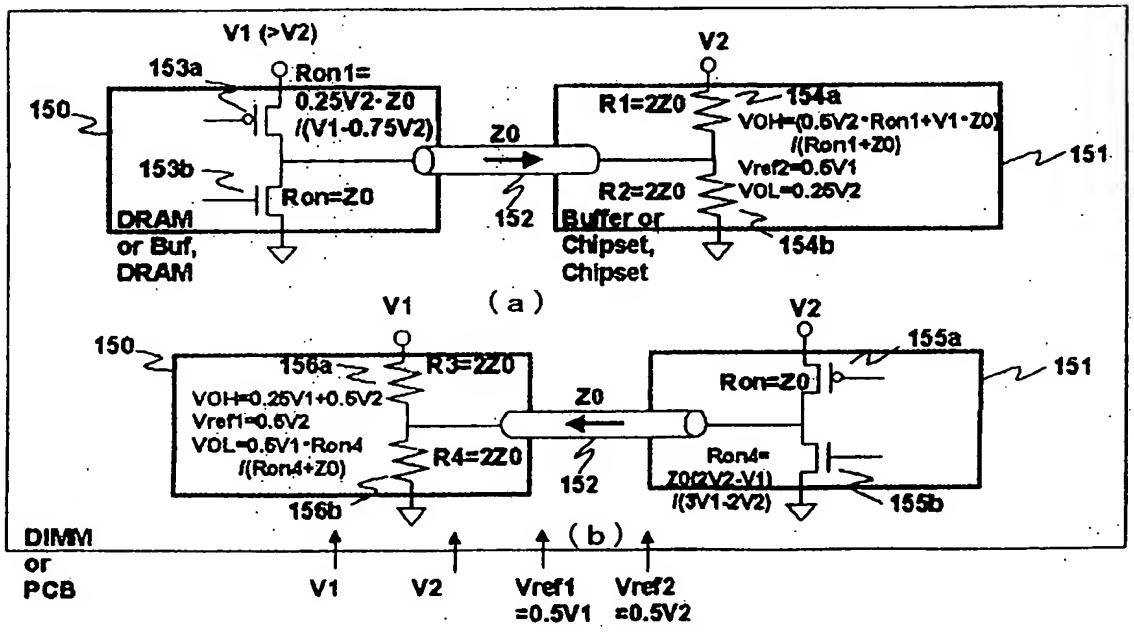

V1 (>V2)
V2
153a
Ron1=
0.25V2-Z0
/(V1-0.75V2)
150
R1=2Z0
154a
VOH=(0.5V2*Ron1+V1*Z0)
/(Ron1+Z0)
Z0
151
153b
Vref2=0.5V1
Ron=Z0
R2=2Z0
VOL=0.25V2
152
DRAM
or Buf,
DRAM
Buffer or
Chipset,
Chipset
154b
(a)
V1
V2
150
155a
156a
R3=2Z0
151
Ron=Z0
VOH=0.25V1+0.5V2
Vref1=0.5V2
Z0
VOL=0.5V1*Ron4
/(Ron4+Z0)
R4=2Z0
Ron4=
Z0(2V2-V1)
/(3V1-2V2)
152
156b
155b
DIMM
or
PCB
(b)
V1
V2
Vref1
=0.5V1
Vref2
=0.5V2

FIG. 54